JULY 1938 TWO SHILLINGS

Wireless World

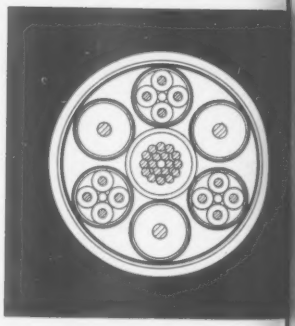
21384

ELECTRONICS

Radio · Television

FORTY-EIGHTH YEAR OF PUBLICATION

XUM



"FOUR-THREE-TWO-ONE-!"

Testing time for guided missiles—with cables providing the nervous system for the control equipment . . . BICC design and manufacture a wide variety of control cables for both ground and airborne use. Standard types are also available for use with ancillary equipment such as ground radar, centimetre radio links and closed circuit television

For outdoor connections

BICC Polypole Couplers are also particularly suitable for use with ground control equipment, since they ensure a tough, permanent, moisture-resistant assembly which virtually eliminates the possibility of conductor breakages at the coupler.

BICC control cables

BRITISH INSULATED CALLENDER'S CABLES LIMITED • 21 Bloomsbury Street, London, W.C.1

XUM

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Pocket size... pocket wise!

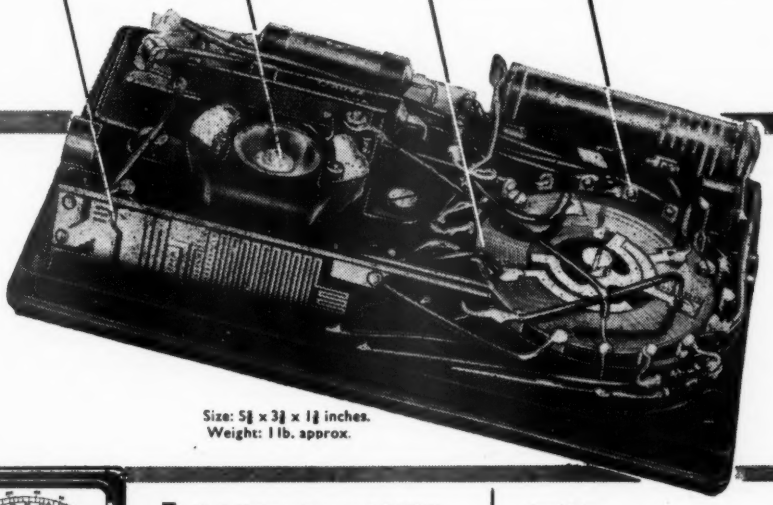
This sturdy multi-range test meter is remarkable for the wide range of test facilities which have been so neatly incorporated. Full advantage has been taken of printed resistor techniques to produce a compact instrument of low weight.

Printed resistance panel for universal meter shunt.

Composite printed resistors and auxiliary switch.

Meter movement is enclosed to give protection against the infiltration of dust.

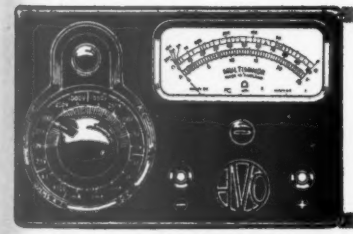
Robust range switch similar to that used in the famous Avo-Meter. Eighteen fixed silver-plated contacts embedded in a ring of high-grade moulding material are swept by a double contact rotor arm.



AVO

Regd. Trade Mark.

Size: 5⅞ x 3⅞ x 1⅞ inches.
Weight: 1 lb. approx.



7 D.C. Voltage Ranges: 0-1,000 V.

5 A.C. Voltage Ranges: 0-1,000 V.

5 D.C. Current Ranges: 0-1A.

2 Resistance Ranges: 0-20,000Ω. 0-2MΩ.

Sensitivity:
10,000Ω/V on D.C. voltage ranges.
1,000Ω/V on A.C. voltage ranges.

Accuracy:
3% of full scale value on D.C.
4% of full scale value on A.C.

For a small additional charge, instruments can be supplied to a higher degree of accuracy.

THE MULTIMINOR

List Price:
19 Ranges · Single Knob Control · £9:10s.
Complete with test leads and clips. Leather case if required 32/6.

● **Write for fully descriptive leaflet.**

AVO Ltd. AVOCET HOUSE · 92-96 VAUXHALL BRIDGE ROAD · LONDON · S.W.1.
VICtoria 3404 (9 lines)

A

improved

SOLARTRON

'packaged' power

sub-units

It's so easy to put in a ready-made, self-contained, completely reliable Power Supply sub-unit!

these are design centre performance figures

	SRS 156	AS 516	AS 517	AS 616	AS 619	AS 754	AS 755
VOLTAGE	±150V	±250V or ±300V	±250V or ±300V	±250V or ±300V	±150V to ±180V	±250V or ±300V	±250V or ±300V
CURRENT	0-40mA	0-50mA	10-100mA	0-1A	0-200mA	0-200mA	0-500mA
A.C. OUTPUTS	6.3V 4A C.T. 6.3V 1A	6.3V 4A C.T. 6.3V 1A	6.3V 4A C.T. 6.3V 2A C.T. 6.3V 1A	6.3V 10A C.T.	6.3V 4A C.T. 6.3V 4A C.T. 6.3V 1A C.T.	6.3V 6A C.T. 6.3V 6A C.T. 6·3V 2A	6.3V 10A C.T 6.3V 5A C.T.
D.C SOURCE IMPEDANCE	<2Ω	0·3Ω	0·2Ω	0·4Ω	0·5Ω	0·4Ω	0·05Ω
STABILISATION FACTOR	400:1	1000:1	800:1	500:1	400:1	500:1	500:1
A.C. SOURCE IMPEDANCE 40c/s—100kc/s	<2Ω	0·1Ω	0·15Ω	0·2Ω	0·2Ω	0·4Ω	0·2Ω
RIPPLE AND NOISE CONTENT	<350μV	100μV	150μV	300μV	100μV	150μV	300μV
DIMENSIONS	9⅛" × 6¼" × 6½" high	9¼" × 6¼" × 6½" high	9¼" × 7½" × 6½" high	19" × 19" × 10½" high	10" × 10" × 6 5/16" high	13" × 6½" × 6½" high	19" × 12" × 8⅞" high
WEIGHT	14¼ lbs	14½ lbs	20½ lbs	150 lbs	21½ lbs	25 lbs	56 lbs

* Better stability factors
* More heater power
* Less ripple and noise
* No increase in cost for this improved performance
* Lower source impedance
* Stability unaffected by capacity loading
* Delivery ex-stock

SOLARTRON **Power Supply Sub-units**

THE SOLARTRON ELECTRONIC GROUP LTD • THAMES DITTON • SURREY • ENGLAND

Telephone: EMBerbrook 5522 · Cables: Solartron, Thames Ditton

XUM

Permanent Magnets Design Advisory Service

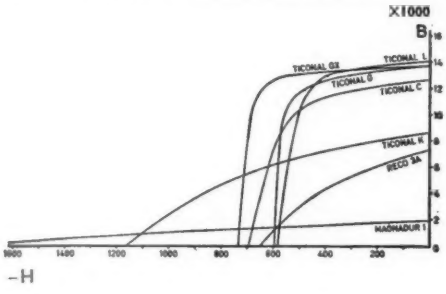
No 4

The Choice of Magnet Materials

Advertisements in this series deal with general design considerations. If you require more specific information on the use of permanent magnets, please send your enquiry to the address below, mentioning the Design Advisory Service.

The Mullard range of permanent magnet materials meets the majority of present day magnet requirements. To assist designers in choosing the correct magnet material for a given purpose, some of the advantages of these materials and a few of their applications, are given below.

'Ticonal' GX has the highest energy content of the commercially available permanent magnet materials. It is difficult and expensive to manufacture and should only be used where minimum size and weight are extremely important with cost



a secondary factor. These magnets are predominantly anisotropic and are only manufactured in block and cylindrical form, with a straight magnetic axis.

'Ticonal' G represents the best compromise between performance and cost of any permanent magnet material available. It is comparatively easy to manufacture into any required shape and gives a high and uniform performance. It is strongly recommended for general purposes and is used throughout the world for the majority of permanent magnet applications.

'Ticonal' L is primarily intended for use in loudspeaker assemblies. A permanent magnet of higher B_d value than is obtainable from 'Ticonal' G has certain technical advantages.

'Ticonal' C has slightly lower magnetic properties than 'Ticonal' G but with a higher coercive force; this material is particularly useful in motors, dynamos and other dynamic applications.

'Ticonal' K is a relatively new material and only certain shapes are available at present. Its magnetic characteristics facilitate the use of very short magnets. It has an exceptionally high coercive force and is recommended in the design of moving coil instrument circuits where a magnet forms the inner core of the system.

'Reco' 3A is isotropic (non-directional) and can therefore be magnetised equally in any direction. It is of comparatively low performance but is particularly suitable for multi-polar applications or inexpensive magnets where high performance is not essential.

'Magnadur' 1 is one of the new ceramic magnets. As it contains no cobalt or nickel it is therefore inexpensive to manufacture. It has an unusually high coercive force and is particularly useful for applications where the magnet is subjected to alternating fields of any frequency.

Principal Characteristics of Mullard Permanent Magnets

MAGNET	BH(max) x 10^6	B_r	H_c	B_d	H_d
'Ticonal' GX	7.5	13,500	720	12,000	625
'Ticonal' G	5.7	13,480	583	11,000	520
'Ticonal' L	5.4	13,500	575	12,000	450
'Ticonal' C	5.0	12,500	680	9,620	520
'Ticonal' K	4.0	9,000	1,300	5,000	800
'Reco' 3A	1.7	7,200	645	4,350	390
'Magnadur' 1	0.95	2,000	1,750	950	1,000

If you wish to receive reprints of this advertisement and others in this series write to the address below.

Mullard

'TICONAL' PERMANENT MAGNETS
'MAGNADUR' CERAMIC MAGNETS
FERROXCUBE MAGNETIC CORES

MULLARD LIMITED, COMPONENT DIVISION, MULLARD HOUSE, TORRINGTON PLACE, W.C.1. Tel: LANgham 6633
MC265A

AUDIO FAIR CROWDS QUEUE TO HEAR THIS OUTSTANDING SPEAKER

H.F.1016

- 10" Die-cast Chassis
- 16,000 gauss magnet
- 10 watts handling capacity
- Patented Stentorian Cambric Cone
- Universal Impedance Speech Coil
  (instantaneous matching at 3, 7·5 and 15 ohms)
- 30-15,000 c.p.s. frequency response
- 35 c.p.s. bass resonance

£8 (inc. P.T.)

Stentorian

T.359 Cone Tweeter Unit.
Provides a very high standard of reproduction when used in conjunction with 'Stentorian' 10" or 12" units. Incorporates High Sensitivity 9,000 gauss magnet, special cone and light-weight coil.
Frequency response: 3,000-17,000 c.p.s.
Overall size: 3½" dia. x 2" deep.
Voice coil impedance: 15 ohms or 3 ohms.
Power handling capacity: 15 watts when used with a 3,000 c.p.s. crossover.
Price: 35/- (inc. P.T.).

If you were unable to visit the Audio Fair, or if you were one of the unlucky ones who could not get into our demonstration room—there's a great thrill still in store for you.

Everyone who heard this remarkable speaker was astounded by the lifelike quality of reproduction. The H.F.1016 incorporates a very powerful magnet assembly, which combines with the patented cambric cone to provide brilliant transient response when the speaker is mounted in a bass reflex cabinet. Designed for use as a single full-range unit, it may also be used with the new Stentorian T.359 Cone Tweeter Unit (or the well-known T.10) as an outstanding two-speaker system at very low cost.

Also acclaimed at the Fair was the new WB.6 Amplifier (£19.19.0 complete). Leaflets on all W.B. products available on request.

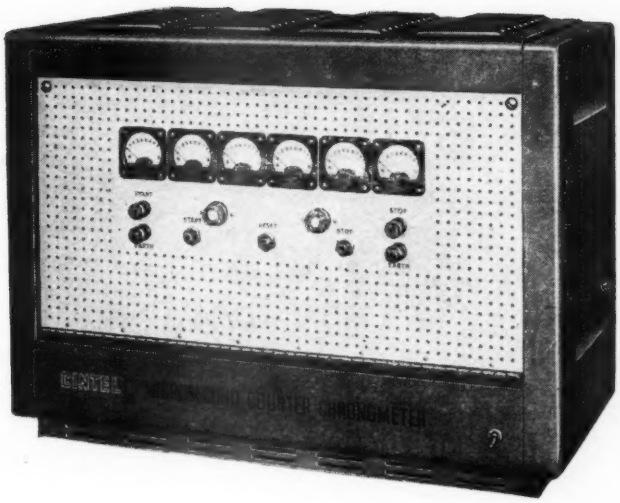
The Stentorian Hi-Fi range includes speakers (8" to 15" dia.), tweeter units, ready-to-assemble cabinets (contemporary and traditional styling) from £5 10s. to £16 16s., the W.B.12 Amplifier and the new W.B. VHF/FM Tuner. See and hear them at all leading Hi-Fi dealers: in case of difficulty, write our London office (109 Kingsway, W.C.2) for name of nearest stockist. Demonstrations at this address every Saturday, 9 a.m. to 12 noon.

WB

WHITELEY ELECTRICAL RADIO CO. LTD · MANSFIELD · NOTTS

XUM

MICROSECOND CHRONOMETER



This equipment is designed to measure small intervals of time to a high order of accuracy and two ranges are provided:

(1) 1 μsec. to 1 sec. in steps of 1 μsec.

(2) 10 μsec. to 10 sec. in steps of 10 μsec.

Accuracy of each range is better than ± 0.005% ± the step interval.

Full details on this and other 'Cintel' Chronometers are available on request.

CINEMA TELEVISION LTD

A COMPANY WITHIN THE RANK ORGANISATION LIMITED

WORSLEY BRIDGE ROAD • LONDON • S.E.26
HITHER GREEN 4600

SALES AND SERVICING AGENTS:
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McKellen Automation Ltd., 122 Seymour Grove, Old Trafford, Manchester, 16

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ANNOUNCE

that from June 30th 1958 the Company will be known as

CIBA (A.R.L.) LTD

Makers of synthetic resins for industry

REDUX	RESOLITE
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AEROLITE	AEROWEB

(registered trade names)

CIBA (A.R.L.) LTD

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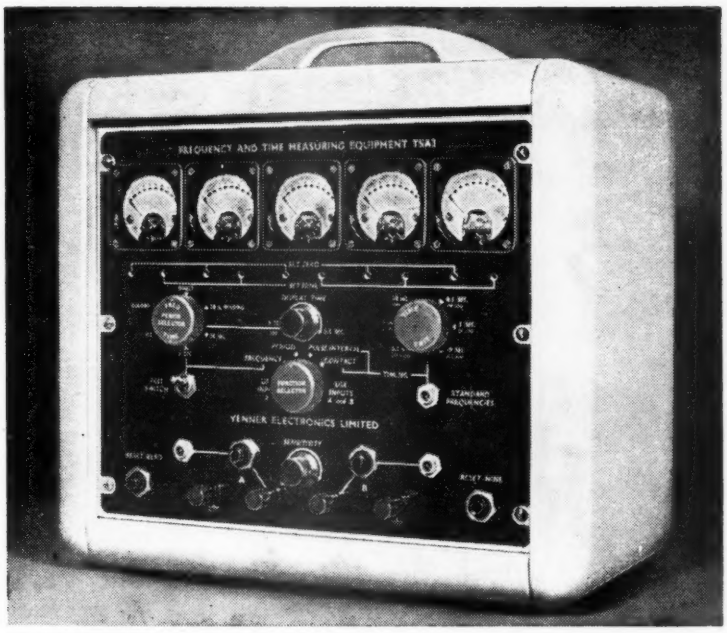
AP 6813



Only One Equipment !

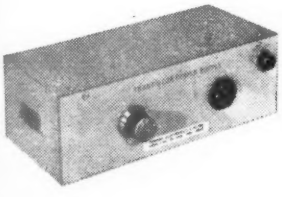
The Exceptional TSA3

Measures frequency up to 50kc/s.
Measures time from 0.1mS to 11½ days.
More comprehensive at the price than any equivalent equipment.
Self checking on five frequencies.
Accuracy exceeds ±0.005.%
Incorporates 106 transistors in 19 plug-in stages.
Digital Time base.
Variable display time from ½ sec. to 5 sec. or infinite.
Low power consumption.
Standard output frequencies at 0.1c/s., 1c/s., 10c/s., 100c/s., 1kc/s., 10kc/s.
0.1 second, 1 second and 10 second sampling times.
Size: 14½ x 17¾ x 11½in.

PRICE £275

TRANSISTOR STABILIZED POWER SUPPLY TYPE TS20

This unit can be fitted inside the frequency meter to enable it to function from EITHER 200/250 v., 50c/s mains, or from 12 v. D.C. at the turn of a switch.
Another important use for the unit is as a source of 8-12 v. D.C. (adjustable) at currents up to 300mA., for use in laboratories, educational establishments or for driving other transistorized equipment. Bench units are fitted with terminals. Size 7½ x 3½ x 2½in. Price £20.



VENNER

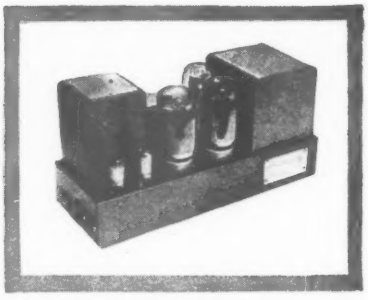
ELECTRONICS LIMITED

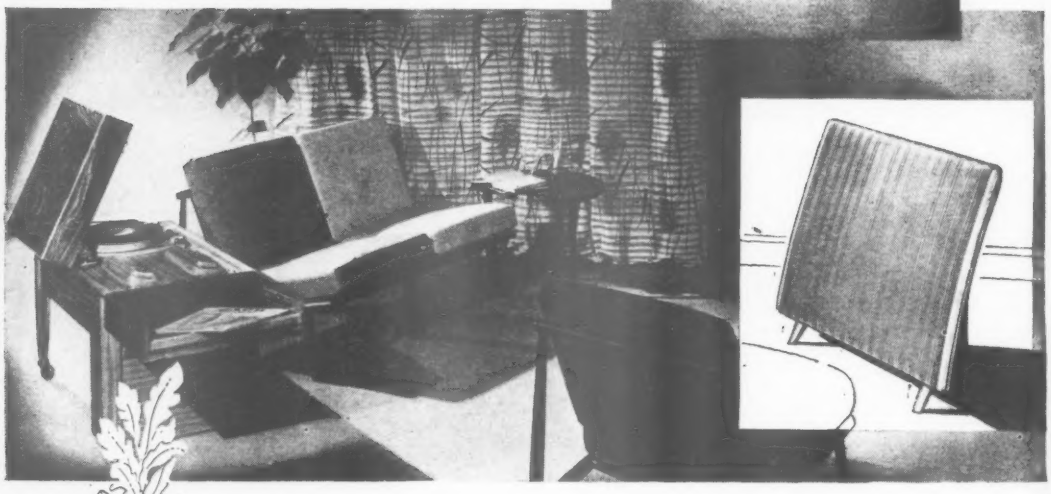
KINGSTON BY-PASS, NEW MALDEN, SURREY. Tel: MALden 2442

A member of the Venner Group of Companies

ACOUSTICAL

For the closest approach to the Original Sound— that your enjoyment and appreciation of music may be unimpeded





Please ask for illustrated literature describing the QUAD II Amplifier, FM Tuner and Electrostatic Loudspeaker.

ACOUSTICAL MANUFACTURING CO. LTD.
HUNTINGDON, HUNTS.
HUNTINGDON 361.

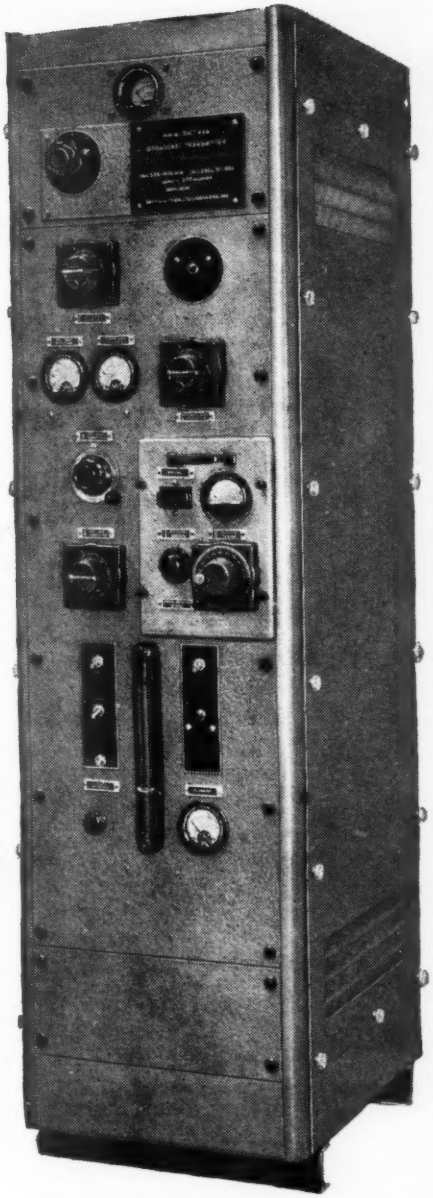
Introducing

THREE NEW MODELS OF THE 'Q' SERIES

1 **MI-8167-Q**—Communications Transmitters (250/350 watt)
This is the latest development of the famous R.C.A. ET-4336-Series and *supersedes* all previous models (H, J, K and L).
The 'Q' Models are supplied with Crystal Oscillators, Master Oscillators, high quality Speech Amplifiers and for **SPEECH PRIVACY—with Speech Inverters and Hybrid Units.**

2 **MI-8167-BRS-Q**
This is the latest model of our MI-8167-BRS Short-wave Broadcast Transmitters (which are in current use in several overseas territories). Supplied with High-Fidelity BRS-M-2A AF-Driver Amplifiers.

3 **MI-8167-BRM-Q**
Designed to operate at any frequency in the broadcast band of 535 to 1,605 Kc. The normal power output (as in the case of the BRS model) is 250 watts, but the Transmitter is capable of producing 275 watts to compensate for losses in antenna tuning equipment. Supplied with BRS-M-2A AF-Driver Amplifiers.



SOME FEATURES OF THE 'Q' SERIES:

- High-Fidelity Modulation.
- No warming-up period necessary.
- Latest-type Xenon filled Rectifiers.
- Ambient Temperature Range—55° to + 75°C.
- Built in Dummy Load for tests off the air.
- Robust and compact construction.
- Metalwork—cadmium plated and passivated.
- Attractive SILVER-GREY HAMMERTONE FINISH.
- Low cost.
- The 'Q' type Transmitters conform to the full requirements of Government Departments and Broadcast Authorities for use in tropical areas.

An illustrated catalogue of the 'Q' Series is now available to all overseas customers. Full technical data on our 5kW Communications and Broadcast Transmitters will also be gladly sent upon request.

Agencies can still be offered in some countries.

The Sign of Quality

BSL

A.I.D. & A.R.B. Approved

BRITISH SAROZAL LIMITED

CONTRACTORS TO COMMONWEALTH, COLONIAL AND FOREIGN GOVERNMENTS

SAROZAL HOUSE, 1/3 MARYLEBONE PASSAGE, MARGARET STREET, LONDON, W.I.

TELEPHONE: LANGHAM 9351 (3 LINES) CABLES: SAROZAL, LONDON

ELECTRONIC TECHNICAL SERVICES
TELEPHONE - RAVENSBOURNE 8951-2

SPECIALISTS
IN THE PREPARATION OF
TECHNICAL HANDBOOKS

Announce

DATA SHEETS
FOR JOINT SERVICE APPROVED ELECTRONIC COMPONENTS

PURPOSE	To provide rapid reference to all the information necessary for the correct employment of Joint Service Type Approved components in electronic equipment.
SCOPE	All data on use, performance, dimensions and mounting derived from the R.C.S.C. series of specifications and lists and from all relevant DEF-5000 series specifications.
FORMAT	Fully indexed and cross-referenced loose leaf data sheets in special binder.
AMENDMENTS RE-ISSUES, ETC.	The book will be kept strictly up-to-date with replacement or additional sheets as required. No manuscript amendments will be necessary.
PUBLICATION	By permission of Her Majesty's Stationery Office. Printed and marketed by our associates H. W. Davies Ltd., 1, Newman Road, Bromley, Kent, from whom order forms and further details may be obtained.

ANOTHER NEW NASHTON INSTRUMENT

DC Valve Voltmeter –Micro Ammeter

SEVEN DC VOLTAGE RANGES UP TO 1000V FULL SCALE

SEVEN DC CURRENT RANGES DOWN TO 0.1 MICRO AMPS FULL SCALE

- ★ Accuracy better than 3% on eleven ranges.
- ★ High input impedance.
- ★ "Balanced to earth" measurements possible.
- ★ High stability against mains fluctuations.
- ★ Top quality moving coil meter to B.S. 89 : 54.
- ★ Fully guaranteed for one year from date of purchase.

This new addition to the NASHTON range of miniaturised electronic test gear is eminently suitable for Reverse Current measurement of Germanium and Silicon diodes: Leakage current measurement of capacitors: Splash current measurement of thermionic diodes and high resistance measurement up to 10,000 Megohms using an external voltage supply.

For further information on Miniaturised Electronic Test Gear write to **Nash and Thompson** *LTD.*

OAKCROFT ROAD · CHESSINGTON · SURREY · ELMBRIDGE 5252

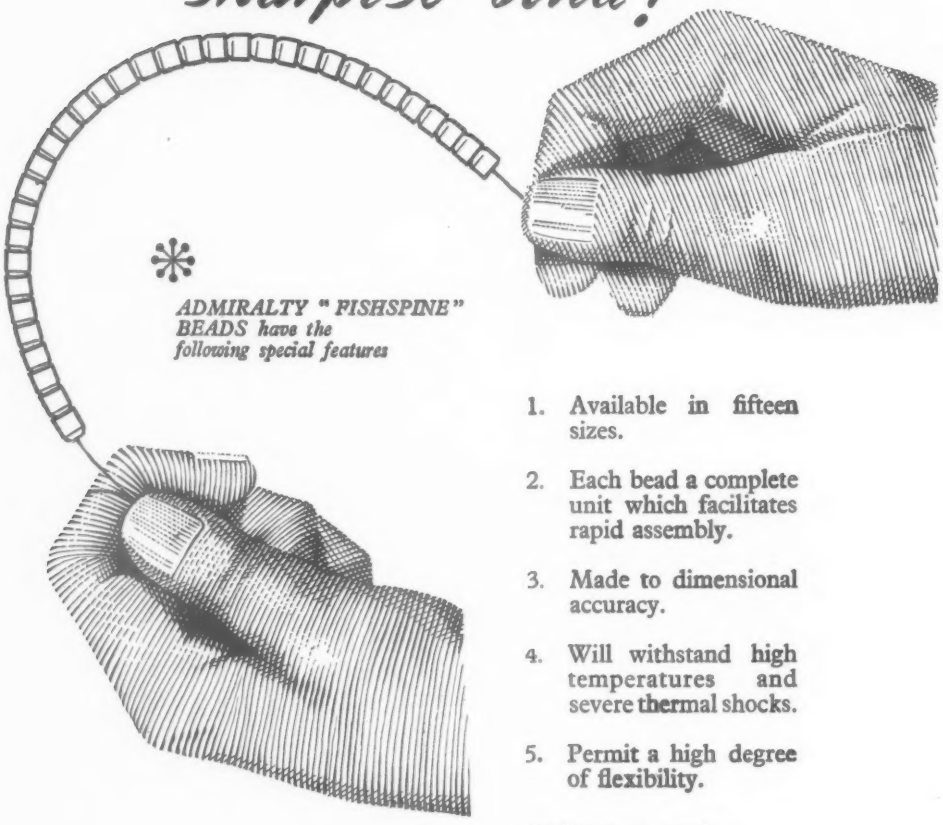
WHG/NT63

Taylor Tunnicliff

ADMIRALTY "FISHSPINE" BEADS

for bare wire insulation

with no gapping on the sharpest bend!



* *ADMIRALTY "FISHSPINE" BEADS have the following special features*

1. Available in fifteen sizes.
2. Each bead a complete unit which facilitates rapid assembly.
3. Made to dimensional accuracy.
4. Will withstand high temperatures and severe thermal shocks.
5. Permit a high degree of flexibility.

Delivery ex stock.

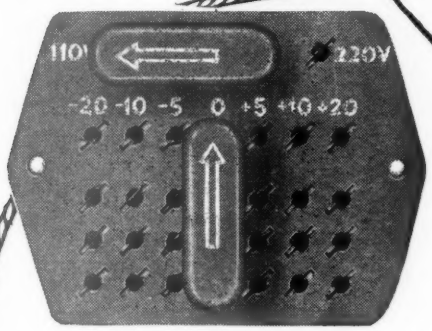
Full technical data, quotations and samples available on request

TAYLOR TUNNICLIFF (REFRACTORIES) LTD
Albion Works, Longton, Stoke-on-Trent, Staffs.
Tel: Longton 33071/2
London Office: 125 High Holborn, W.C.1
Tel: Holborn 1951/2

MARKINGS IN WHITE TO CUSTOMERS' REQUIREMENTS

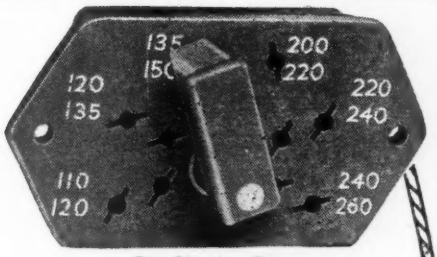
McMURDO
Multi-Way Voltage Selectors

14 WAY
Type B279001
BLACK P.F. MOULDING



4 Pin Shorting Plugs

6 WAY
Type XVS/6
NYLON LOADED P.F. MOULDING

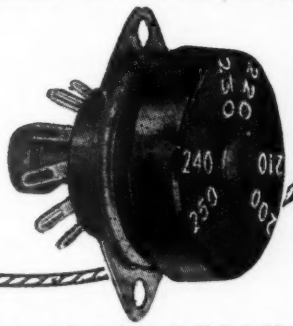


3 Pin Shorting Plug

4 WAY
Type BVS/4
BLACK P.F. MOULDING

3 Pin Shorting Plug

6 WAY
MINIATURE
Type BMVS/6
BLACK P.F. MOULDING



Standard B9A (Noval) Valveholder with 2 Pin Captive Shorting Plug

Send for full details to :—

THE McMURDO INSTRUMENT CO. LTD., ASHTEAD, SURREY. Tel: ASHTEAD 3401

MVS15

The development and manufacture of Loudspeakers for all purposes has been our business for over 30 years. Whatever the application, we are proud to have assisted in equipping many millions of radio and television receivers throughout the world with Loudspeakers which, in design and performance, have set a standard of their own.
Loudspeakers
for all purposes
ROLA
CELESTION
Rola Celestion Ltd.
FERRY WORKS · THAMES DITTON · SURREY · ENGLAND
Telephone: EMBerbrook 3402/6 Cables: VOICECOIL, THAMES DITTON, ENGLAND

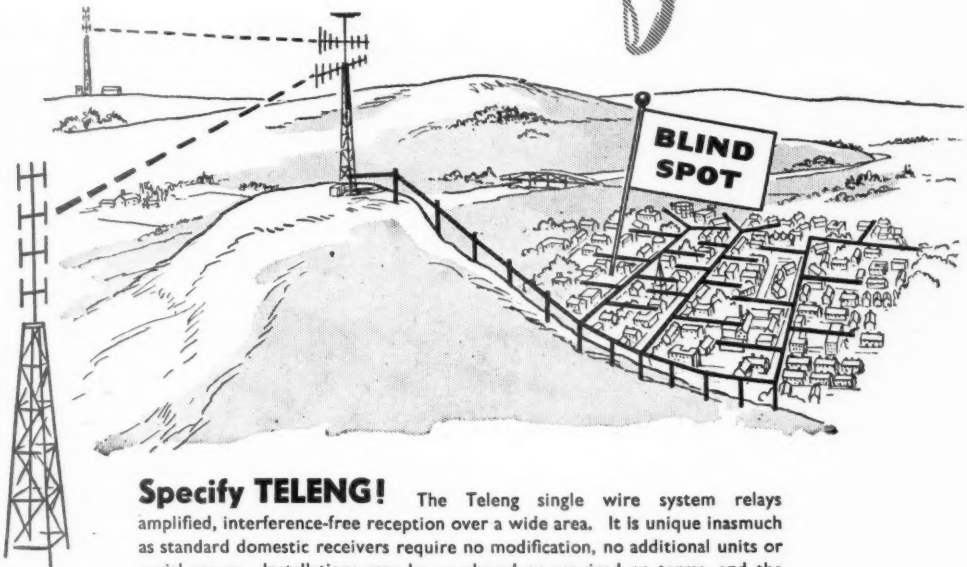
AT YOUR SERVICE . . . .

TELENG *Experience*

in planning **TV/FM RELAY SYSTEMS**

to meet ALL situations

Geographical obstacles to good reception present a challenge to the radio engineer, a challenge which has been met and defeated by the Teleng TV-FM Relay System. Screened areas, where reception has hitherto been indifferent, or perhaps even impossible, can now convert those obstacles into natural advantages.



Specify TELENG! The Teleng single wire system relays amplified, interference-free reception over a wide area. It is unique inasmuch as standard domestic receivers require no modification, no additional units or aerial arrays. Installations may be purchased or acquired on terms, and the fullest technical advice in planning, operation and maintenance is always available.

TELEFUSION ENGINEERING LTD.

ONE OF THE TELEFUSION GROUP OF COMPANIES

Teleng Works, Church Road, Harold Wood, Romford, Essex. Tel: Ingrebourne 2901

THE SERVISCOPE

REGD TRADE MARK

DC TO 6 Mc/s

TIME AND VOLTAGE CALIBRATION

A PORTABLE HIGH PERFORMANCE MEASURING OSCILLOSCOPE

★ INCORPORATES AN ENTIRELY NEW TYPE OF TIME BASE
formerly only available on the most expensive American oscilloscopes.

★ 18 PRE-SET CALIBRATED SWEEP SPEEDS FROM
.5 sec/cm to 1 μ sec/cm

★ AUTOMATIC TRIGGERING OR TRIGGER LEVEL SELECTION

★ DC COUPLED UNBLANKING

★ 9 CALIBRATED Y SENSITIVITIES
FROM 100 mV/cm to 50V/cm ALL DC TO 6 Mc/s

★ SWEEP EXPANSION TO OVER 10 SCREEN DIAMETERS

★ BUILT-IN TV SYNC SEPARATOR

★ ULTRA BRIGHT 3″ FLAT FACE CRT

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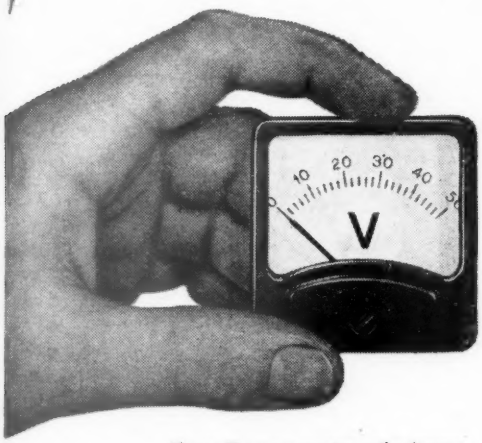

Above: 2" square moving coil voltmeter

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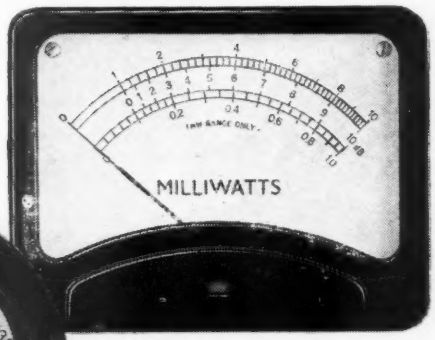
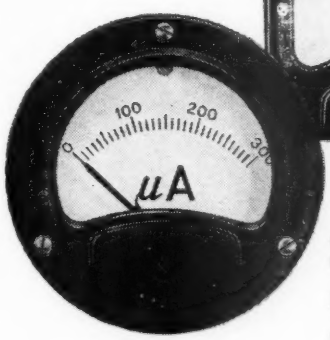


Above: 3"x 4" rectangular absorption wattmeter



Left: 2½" round moving coil microammeter

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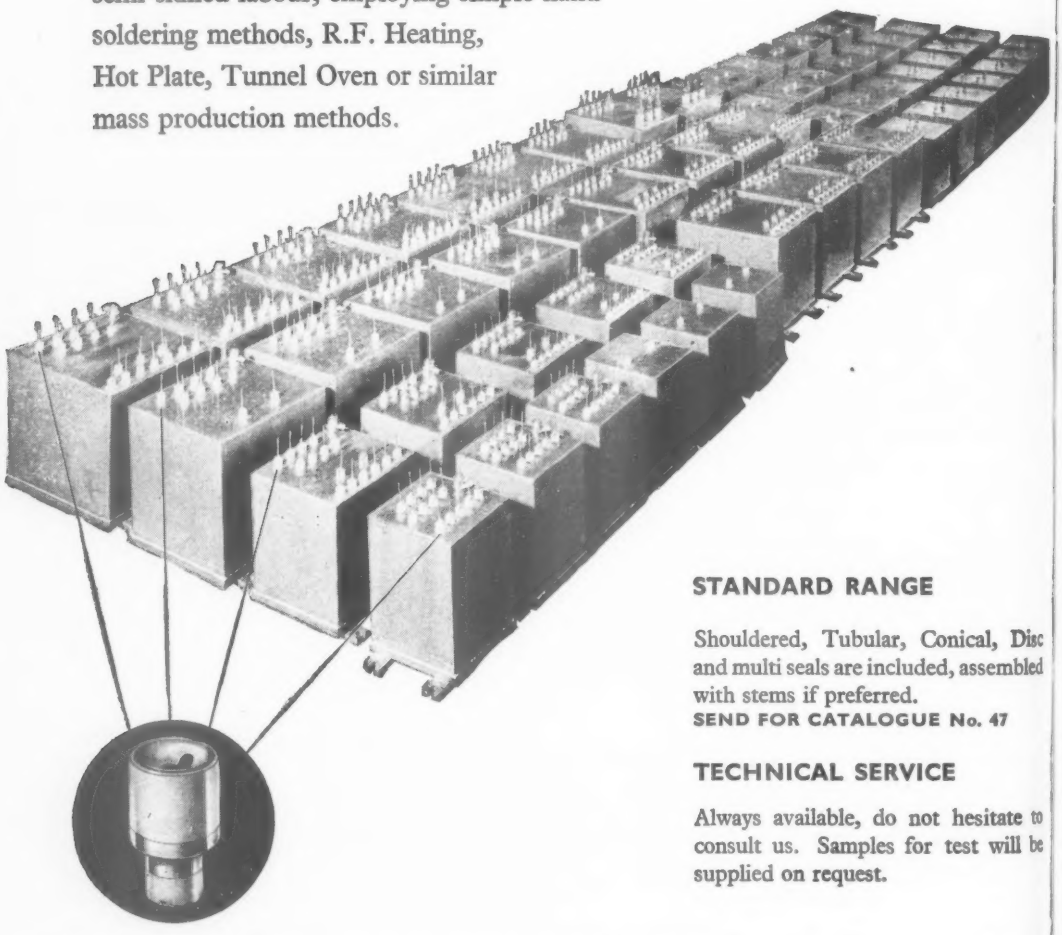

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Base Diameter .....0·64"

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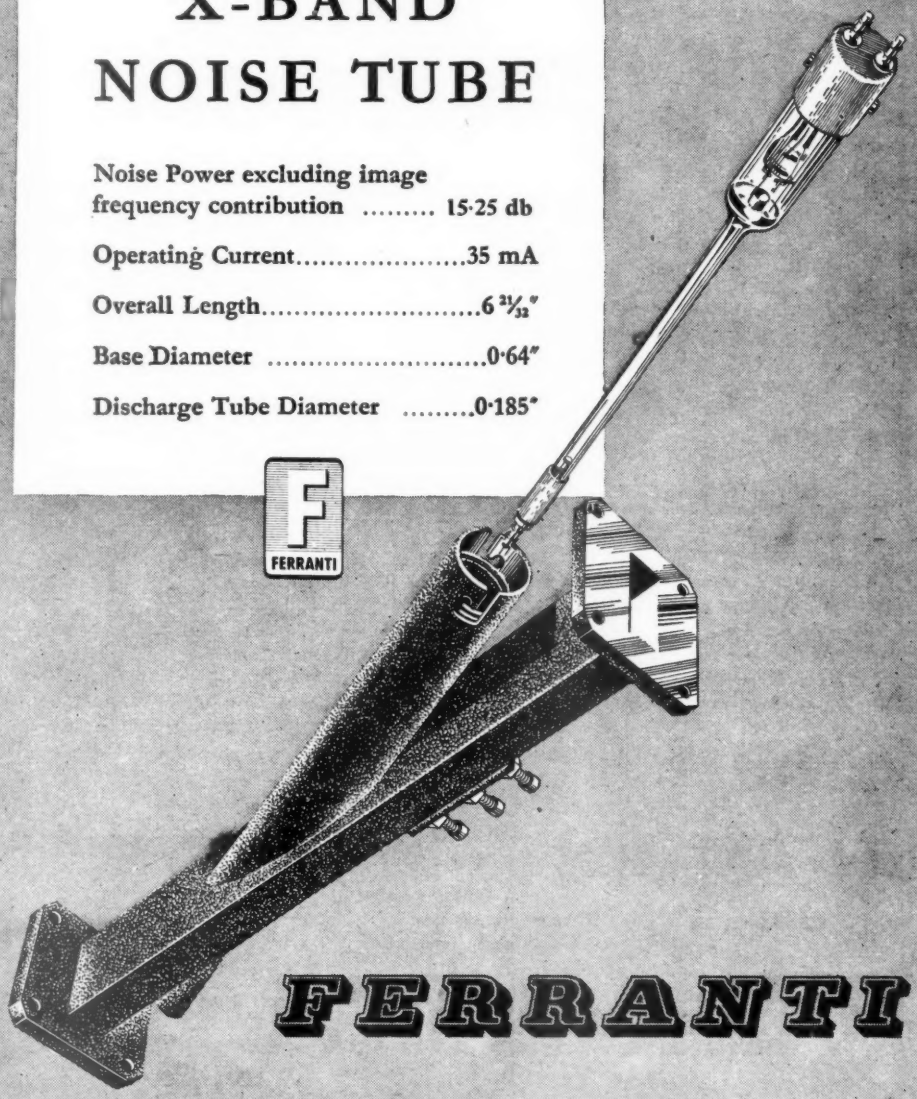

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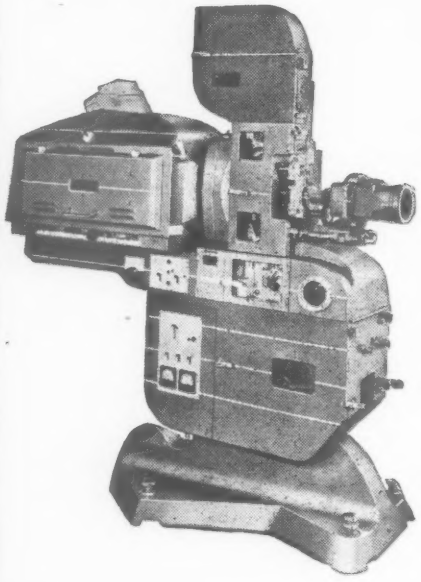

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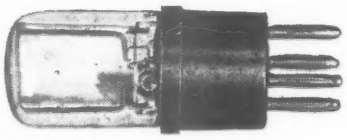

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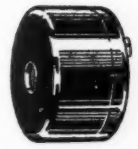

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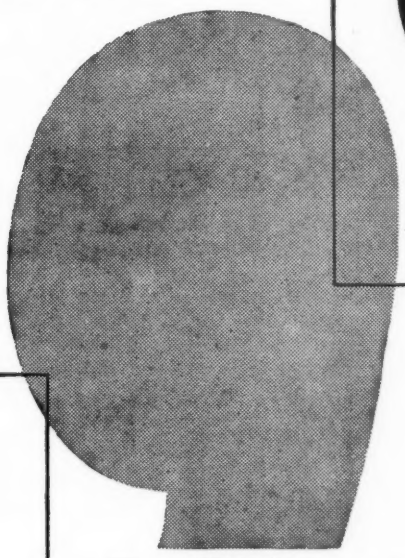

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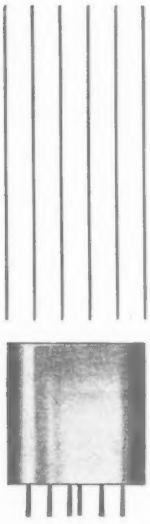

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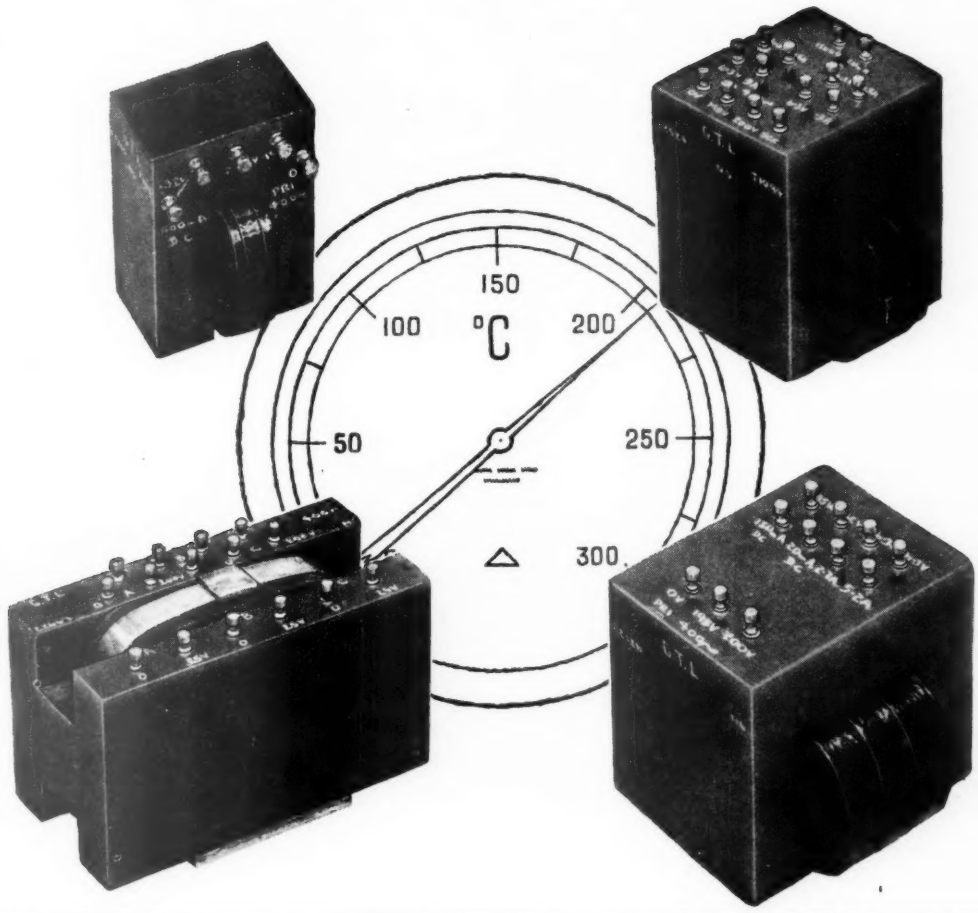

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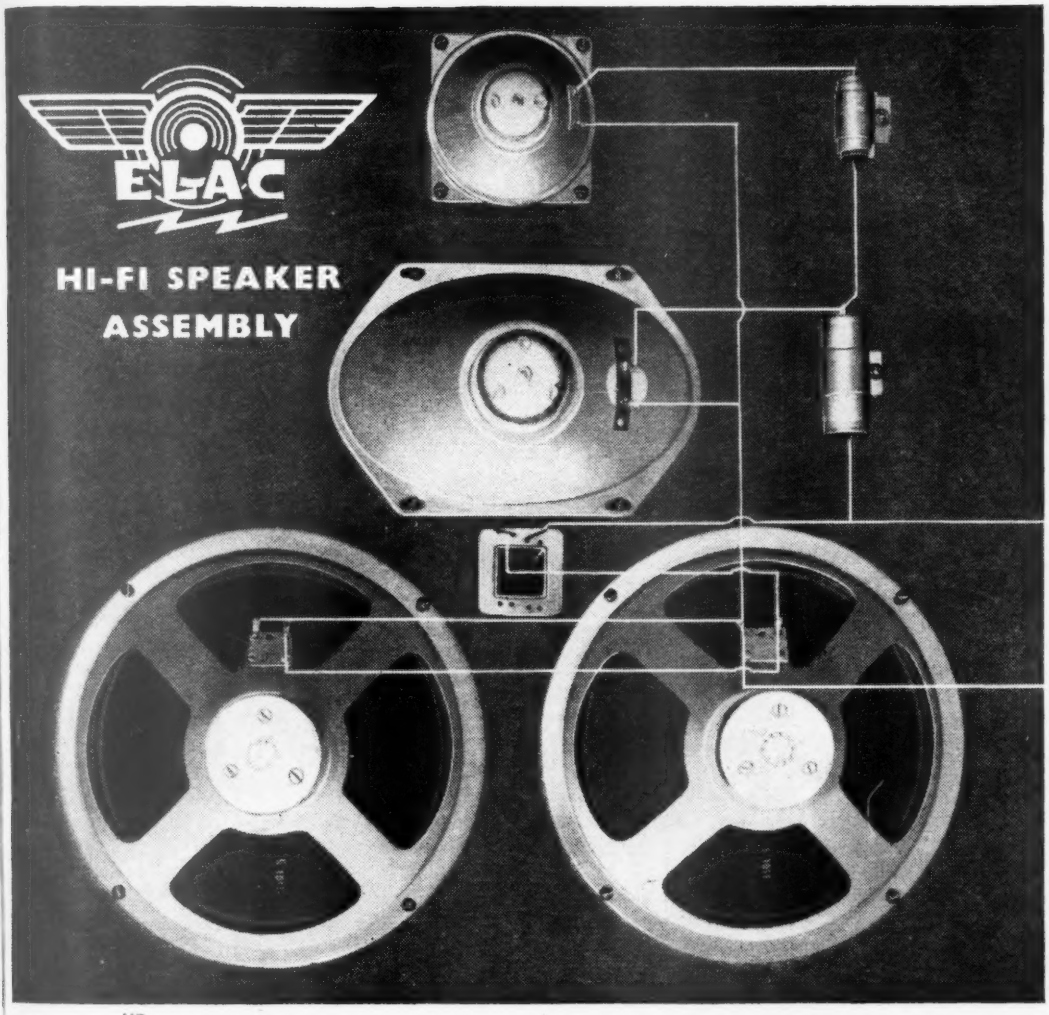

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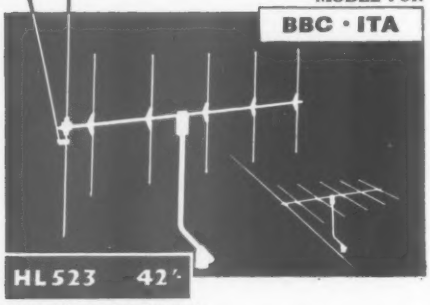

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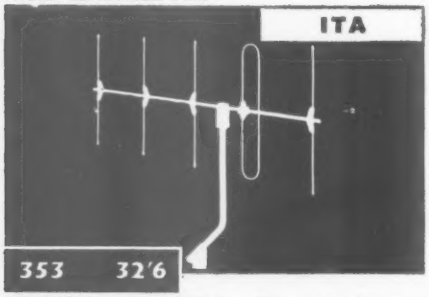

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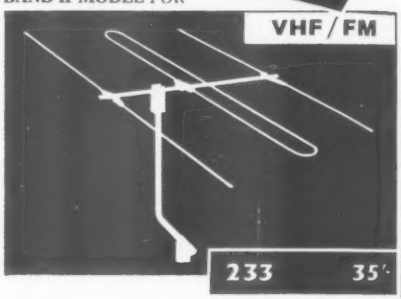

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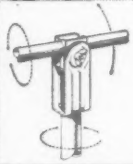

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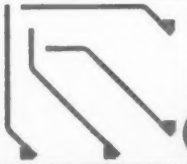

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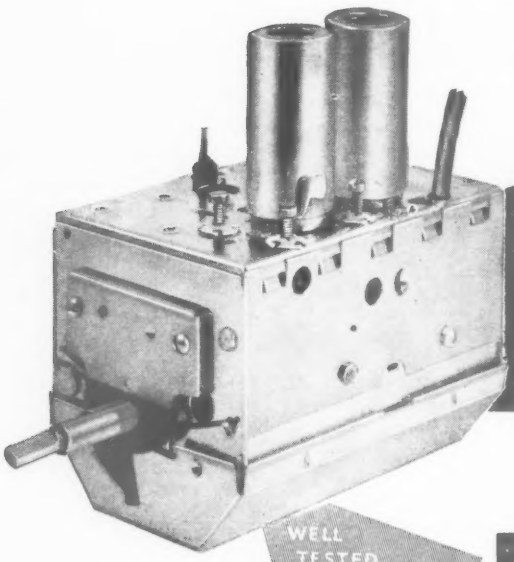

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Both inputs 500k plus 10 pfd.

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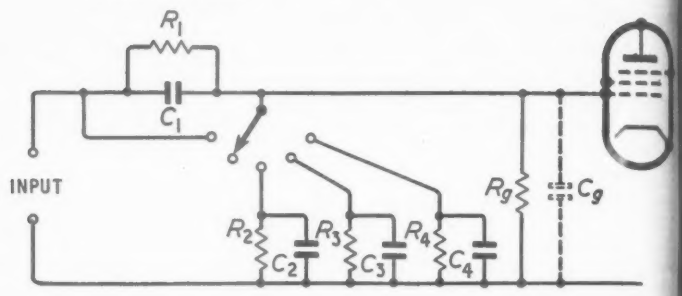
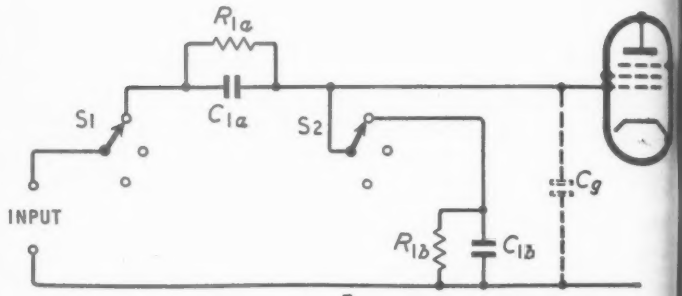


Modern Oscilloscope Practice



The June issue of ELECTRONIC & RADIO ENGINEER contains a review of modern practice in general-purpose oscilloscopes. The article aims at providing the potential user with information about the performance obtainable, particularly when measurements of voltage and time are required, together with information about the type of circuitry currently employed.

Original articles by leading authorities are a prominent feature of ELECTRONIC & RADIO ENGINEER. *Regular readership will keep you in constant touch with progress in the entire field of electronics, radio and television.*

ARTICLES IN THE JULY ISSUE WILL INCLUDE

Thermistors
A commonsense approach to thermistor applications with information on the types of thermistor available and their operating characteristics. A brief description of thermistor manufacture is also included.

Bifilar-T Trap
Some audio-frequency applications of the bifilar-T trap are described, and it is shown how the frequency response can be modified by the addition of inductors or capacitors to provide various useful characteristics.

ALSO
The unique monthly Abstracts and References feature compiled by the Radio Research Organization of the Department of Scientific and Industrial Research.

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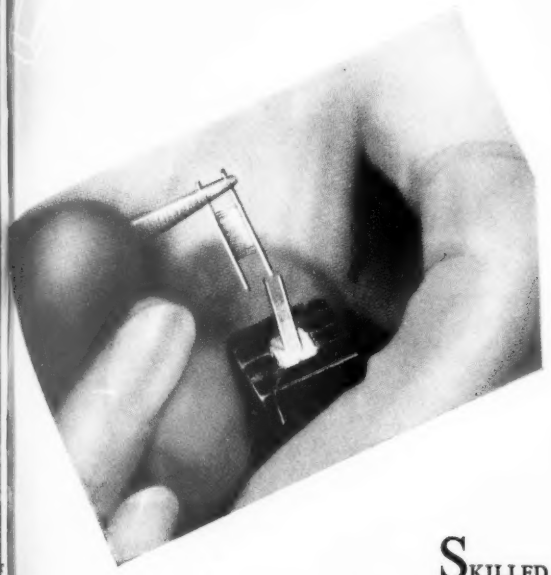

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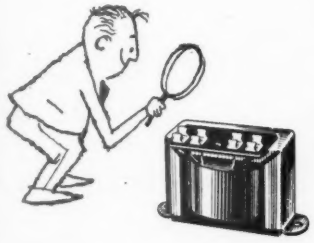

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TYPE	NOM. VOLTAGE	TYPE	NOM. VOLTAGE	TYPE	NOM. VOLTAGE
Z2A33	3.3	Z2A33	3.3		
Z2A36	3.6			Z2A33	3.3
Z2A39	3.9	Z2A39	3.9		
Z2A43	4.3				
Z2A47	4.7	Z2A47	4.7	Z2A47	4.7
Z2A51	5.1				
Z2A56	5.6	Z2A56	5.6		
Z2A62	6.2				
Z2A68	6.8	Z2A68	6.8	Z2A68	6.8
Z2A75	7.5				
Z2A82	8.2	Z2A82	8.2		
Z2A91	9.1				
Z2A100	10	Z2A100	10	Z2A100	10
Z2A110	11				
Z2A120	12	Z2A120	12		
Z2A130	13			Z2A150	15
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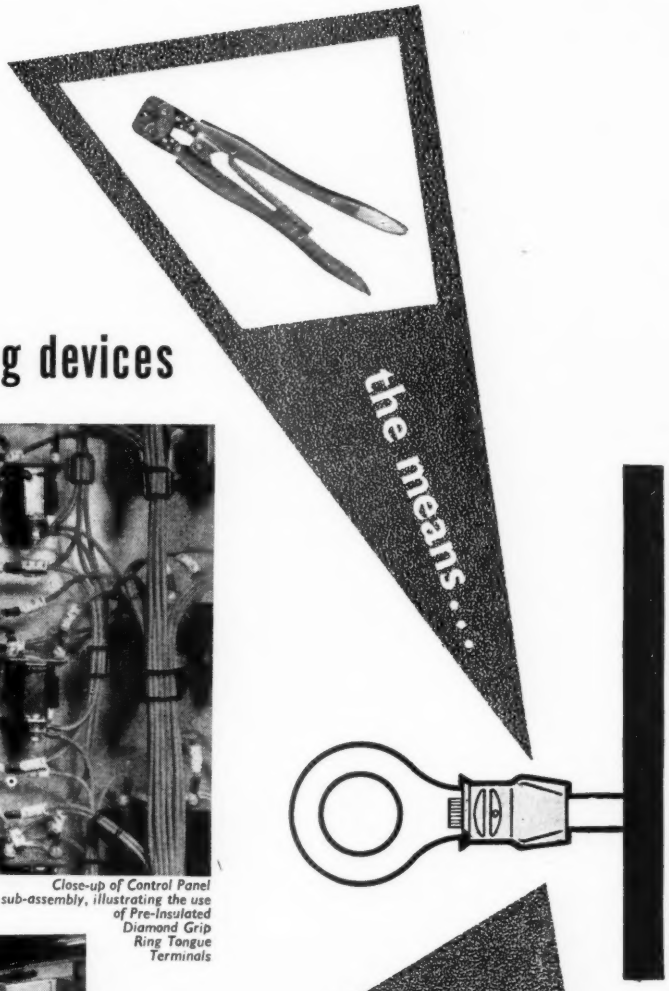
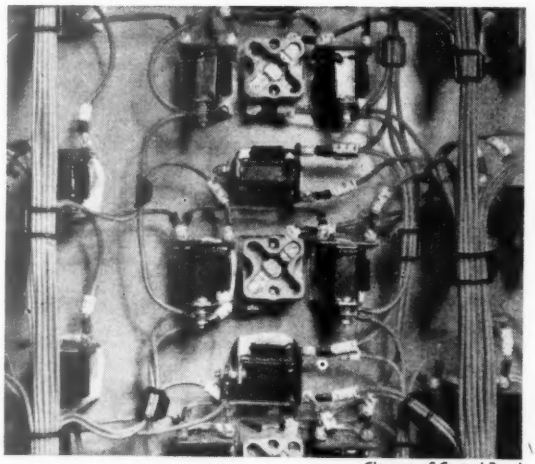
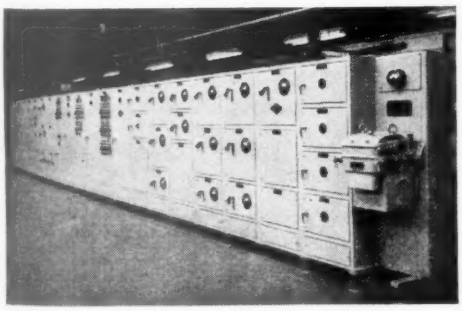




Close-up of Control Panel sub-assembly, illustrating the use of Pre-Insulated Diamond Grip Ring Tongue Terminals



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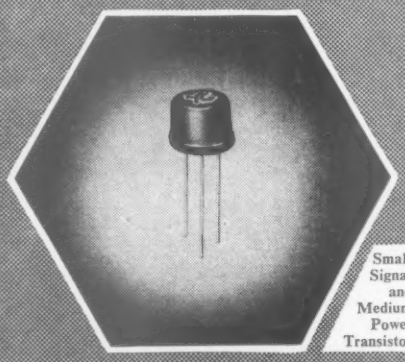
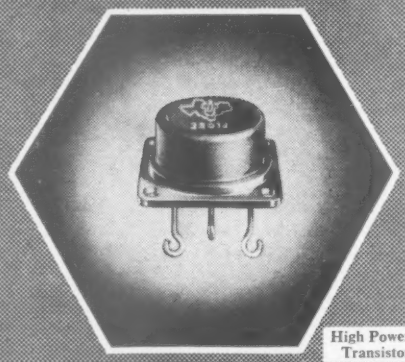
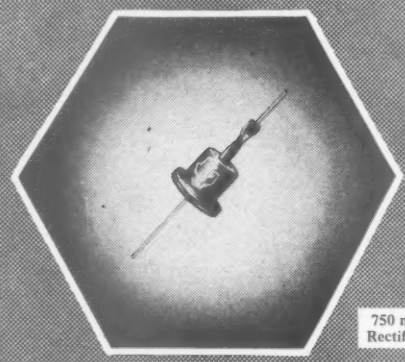


Small Signal and Medium Power Transistor



High Power Transistor



750 mA Rectifier

All illustrations are actual size

Silicon Transistors

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This range of general purpose transistors is used for high gain, low level applications. Special features are :—negligible leakage current, a minimum alpha cut-off frequency up to 20 Mc/s, and a tetrode series providing 16 db gain at 30 Mc/s.

Medium Power

These 4-watt diffused base silicon transistors are ideally suitable for output stages in servo amplifiers. A pair in push-pull operation provide sufficient power to drive many types of servo motors. Two types are available, one with a maximum collector voltage of 60, the other of 100; the former is particularly useful for operating from 28-volt battery supplies.

High Power

Texas high-power transistors permit remarkable miniaturisation of power equipment. A collector dissipation of 37½ watts, with complete reliability, in such a small device, can only be achieved by using silicon. Furthermore, these transistors have a typical alpha cut-off frequency of 5 Mc/s.

Silicon Diodes

Medium Power Rectifiers

The new Texas diffused silicon technique has brought a fundamental change in semiconductor rectifiers. Peak inverse voltages up to 600 are featured in each of two ranges now readily available :—a metal-case rectifier provides a mean rectified current of 750 mA, and a glass-seal type provides 400 mA together with a forward to reverse current ratio of $2 \times 10^6 : 1$.

Computer Diodes

These miniature glass sealed diodes have a maximum recovery time of 0.3 micro sec with a forward current rating of 100 mA; there are three types with P.I.V. ratings of 50, 100 and 150 volts. The capacitance is 2.7 pico-farads at – 10 volts, 1 megacycle.

Complete data sheets are available on request.

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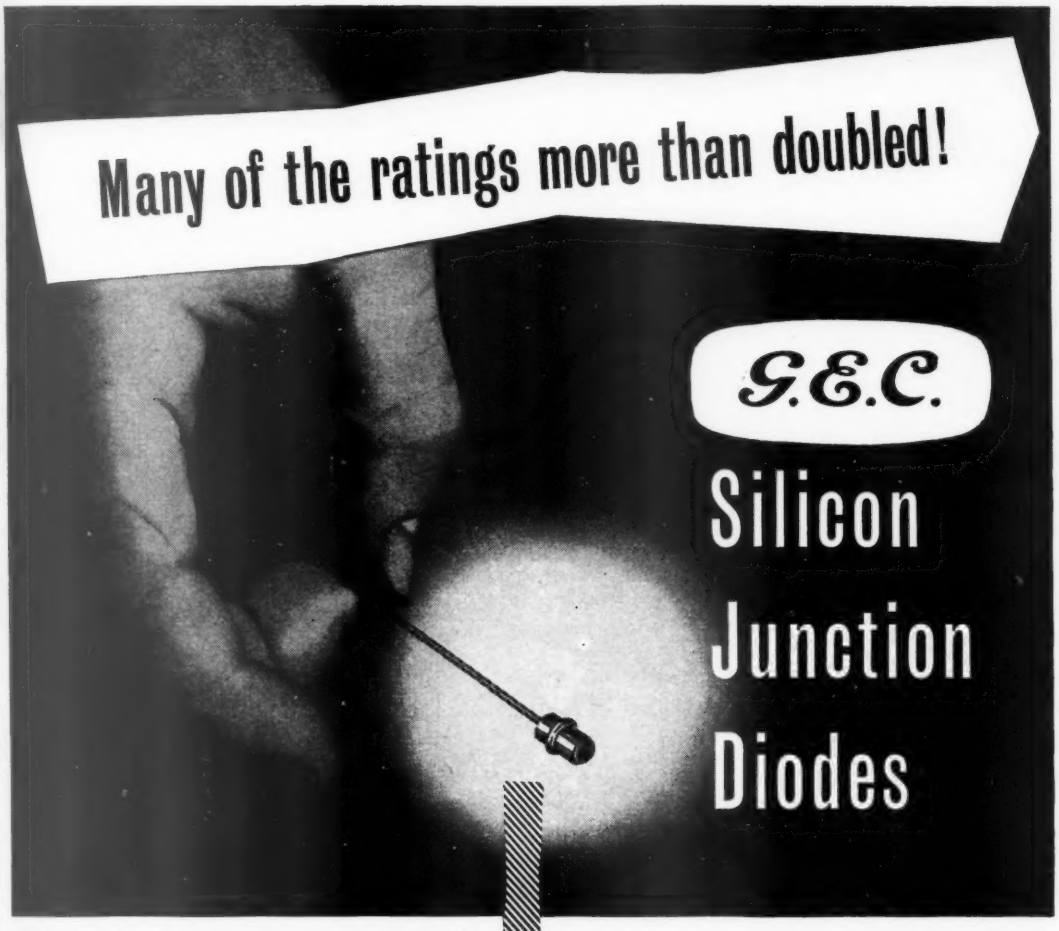

Although many of the ratings are increased, the price of these diodes has been reduced. As a result of the outstanding thermal properties the same increased rating is possible with capacitive or resistive load. The diodes are suitable for high temperature operation and have extremely high ratios of forward to reverse resistance.

Fast recovery time computer diodes are in development. The first of the range to become available is the EW78 which is suitable for use up to 100 Mc/s.

LOW VOLTAGE TYPES

SX641 SX642

Suitable for use as Second Detectors at frequencies of up to 10 Mc/s and for the majority of other low power circuit functions. The rectified current rating at 25° C is 300 mA.

HIGH VOLTAGE TYPES

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Circuit Arrangements	Max rectified current (mA)			RMS input voltage (V)			DC output voltage (V)		
	SX643	SX644	SX645	SX643	SX644	SX645	SX643	SX644	SX645
Half-wave	280	210	210	64	106	140	90	150	200
Bi-phase	560	420	420	64-0-64	106-0-106	140-0-140	90	150	200
Bridge	560	420	420	128	212	280	180	300	400

For further information, please write to the G.E.C. Valve & Electronics Department

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For further particulars of both these instruments, please write for leaflets G126.

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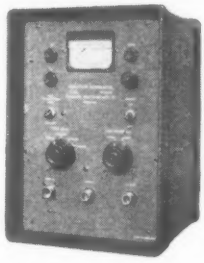

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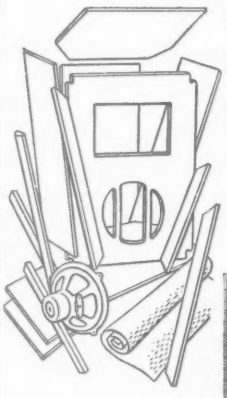
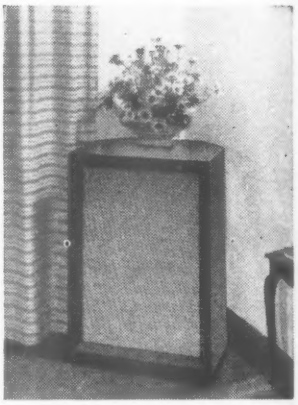


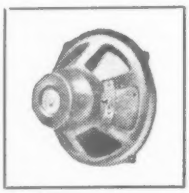
A simple kit brings true high-fidelity within your means



NO HEADACHES
with this kit of parts. Everything you need to build an acoustically perfect loudspeaker is here; including the famous Grampian 1255/15 speaker unit, grille material and working diagrams. All parts are accurately finished, machined and drilled, only assembly and polishing to suit your taste remains to be done. Ingeniously designed for either a corner or flat against the wall, the cabinet will enhance your room — to say nothing of your listening!

PRICE of complete kit including 1255/15 Grampian high-fidelity speaker £20

Deferred terms available if desired on complete kit or speaker and cabinet purchased separately.



The well-known Grampian 1255/15 high-fidelity speaker unit may be purchased separately if required. It is a 12in unit especially designed for use with high quality amplifiers. It has an extended frequency coverage of from 20 to 15,000 c/s with exceptional performance over the useful audio range. Price of 1255/15 unit only £9.

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Decca Decola radiogram with 3-speed auto-change gram unit, three 12in. speakers and eight waveband radio with pushbutton control	£85 0 0
Pye Black Box record reproducer, 3-speed auto, beautiful condition	29 gns.
Wharfedale W15.FS bass unit	£15 0 0
Leak T.L.10 amplifier and Point-One pre-amplifier	£22 0 0
R.D. Baby de luxe amplifier and control unit	£14 0 0
Collaro 2010 transcription unit with transcription pickup and diamond L.P. stylus	£18 0 0
Goodmans Audiom 60 12in. bass speaker	£7 10 0
Sound Sales A/M tuner with variable selectivity	£8 0 0
RCA Orthophinic amplifier and control unit	£32 0 0
Lowther FM tuner with magic eye, very sensitive	£15 0 0
BSR 3-speed auto change gram unit	£6 0 0

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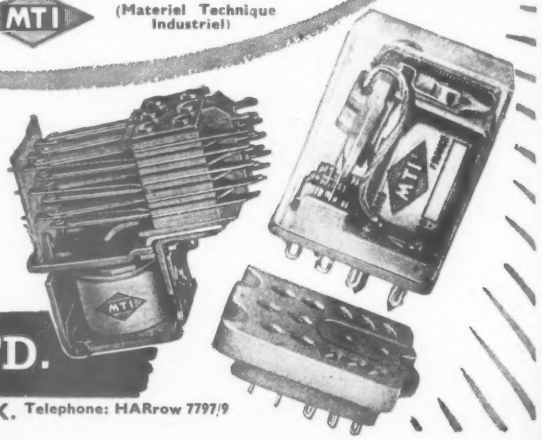

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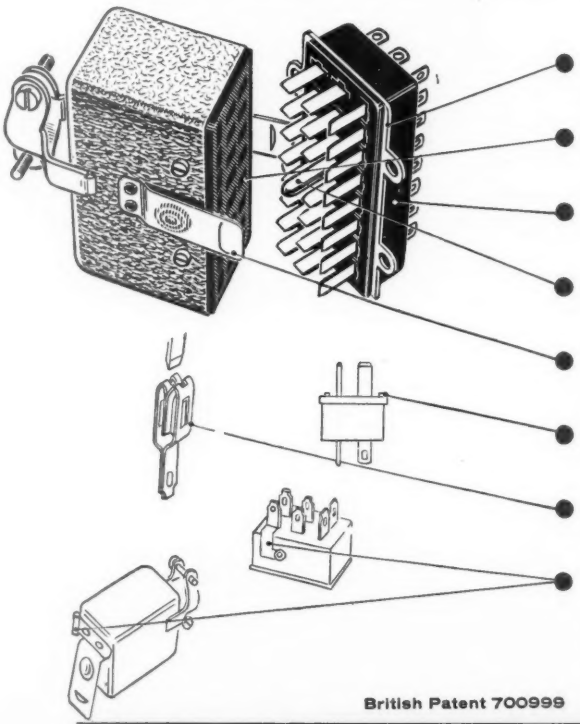
"MULTICON" PLUGS AND SOCKETS

The full range consists of 2, 4, 6, 8, 10, 12, 18, 24 and 33-pole sizes. Illustrated is the 24-pole size.

Working voltage: 1,000 volts D.C. or A.C. (peak) or 500 volts D.C. or A.C. (peak) in tropical use.

Current rating: 5 amps. D.C. or A.C. (R.M.S.) per contact.

Average contact resistance: below 0·002 ohms.



Metal flanges moulded into the body to ensure flush mounting and to avoid alignment difficulties.

Terminal numbering moulded into plug and socket bodies to facilitate wiring and cableform testing.

Single-piece nylon-filled body mouldings provide high insulation and tracking resistance.

Large pin locator contact facilitates engagement, especially in unitor applications.

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Four distance pips keep mating faces apart and eliminate moisture traps between plug and socket faces.

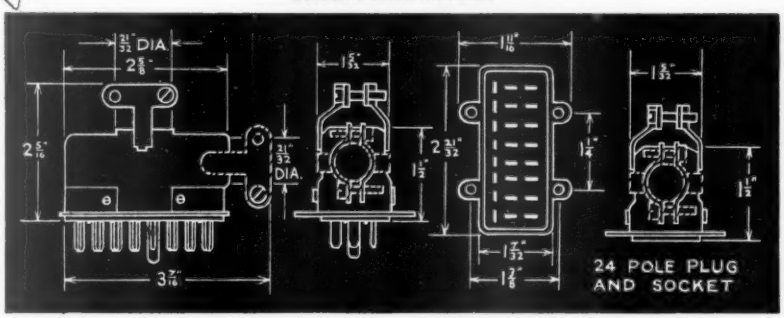
Socket clips have split limbs with four areas in contact with each plug blade ensuring absolute reliability of contact.

Earthing of plug or socket covers is achieved by either:

internal connecting link from a contact to cover, OR

rivetted earth tag to outside of cover.

British Patent 700999



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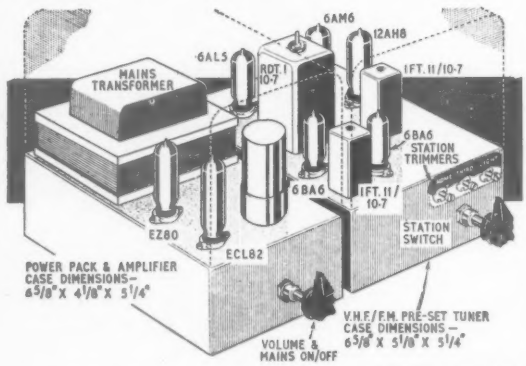
INTRODUCING THE COMBINED POWER PACK AND AMPLIFIER FOR THE "MAXI-Q" PRE-SET OR VARIABLE F.M. TUNER WHICH NOW OFFERS YOU A COMPLETE RECEIVER



Full constructional details, point-to-point wiring diagrams and alignment instructions for building the **"MAXI-Q" COMBINED POWER PACK AND AMPLIFIER, PRE-SET F.M. TUNER** and also the **VARIABLE TUNED** version are given in Technical Bulletin DTB.8, **1/6.**

POWER PACK AND AMPLIFIER. This unit consists of Mains Transformer, EZ80 and ECL82 valves, Volume Control complete with mains on/off switch and is housed in a gold-finished case. Power supplies available for any tuner—Heater 1.5 amps at 6.3V H.T. from 220 V. at 50 mA to 265V. at 20 mA.

The unit is available completely wired and ready for use at **£5/10/-,** plus 2/6 carriage or available in kit form at **£5.**

PRE-SET F.M. TUNER. Completely punched chassis, screens and bronze-finished cover, **19/-.** Station Indicator Plate, **1/1.** Three-position switch, **4/3.** Station Condenser Trimmers, 3-9 pF, **2/-.**

RATIO DISCRIMINATOR TRANSFORMER. RDT **1/10.** 7 Mc/s. Secondary winding of bifilar construction, iron dust core tuning, polystyrene former, silver mica condensers. Can size 1¼in. sq. × 2½in. high, **12/6.**

I.F. TRANSFORMER, IFT.11/10.7 Mc/s. Miniature I.F. of nominal frequency 10.7 Mc/s. The "Q" of each winding is 90 and the coupling critical. Can size 13/16in. sq. × 1⅞in. high, **6/6.**

COILS, TYPE L1, T1 and T2. Specially designed for use in this unit, are wound on polystyrene formers complete with iron dust core tuning, **3/11** each.

THE "MAXI-Q" PRE-SET F.M. TUNER is available completely wired, assembled, valved and housed in a sturdily made gold-finished cover at **£8/11/5,** plus **£3/8/7** P.T. = **£12** (carriage 3/-).

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GENERAL CATALOGUE covering technical information on full range of components, **1/-,** post free.

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★ No cover and cable clamp worries. We connect your cable to plug or socket and pot the assembly in polythene. ★ 18 connections in less than 1 inch diameter. ★ Standard B9A valveholder mounting. ★ Nylon loaded P.F. mouldings. ★ Cadmium plated or gold plated pins and contacts.

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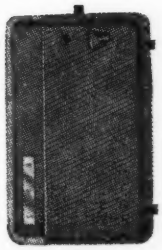
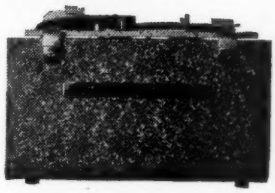
MPC19

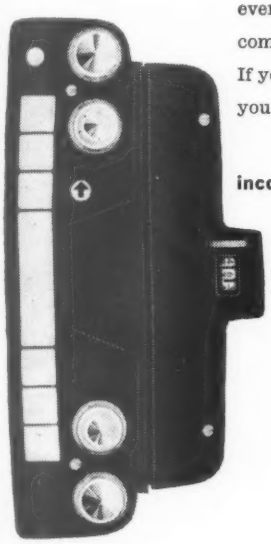
scintillating sound





There are more features in the new Simon SP.4 than have ever before been gathered into any portable tape recorder. Exclusive to the SP.4 is the Simon Automatic Deck, fully 'push-button-controlled' and incorporating automatic tape reversal. A 10-watt ultra-linear amplifier adds to the technical excellence which is matched by elegant styling, and made even more attractive by a price that completely belies the outstanding performance. If you really appreciate first-class recorded sound, you will be thrilled to hear the Simon SP.4.

The lid is detachable. Both case and lid are covered with genuine Rexine in attractive dual tone colours. Styling: Peter Bell, M.S.I.A.



incorporating the new Simon fully automatic tape deck

and these exclusive features:

AUTOMATIC TAPE REVERSAL *without button pressing or spool transposing*

3-WAY MIXING FACILITIES on both record and playback

10 WATTS OUTPUT from ultra-linear push-pull amplifier

PUSH-PULL OSCILLATOR reduces noise and hum to minimum

BASS AND TREBLE LIFT AND CUT with independent controls

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SYNCHRONOUS MOTOR mains frequency controlled for accurate speed

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high fidelity **TAPE RECORDER**

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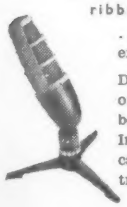

. . . to do justice to the excellence of the SP.4.

Dual impedance head, output sensibly flat between 50-12,000 cps. In handsome presentation case, head only or with tripod desk stand.

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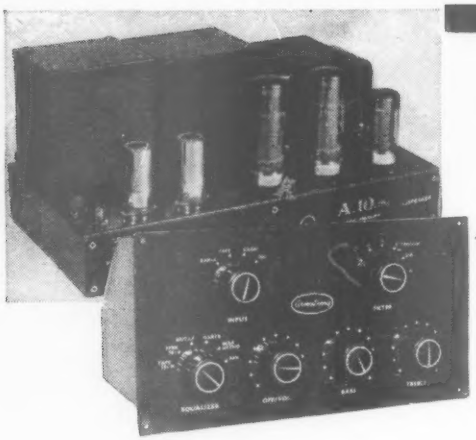

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HIGH FIDELITY AMPLIFIER & PRE-AMPLIFIER CONTROL UNIT

BRIEF SPECIFICATION: *Output:* 10 watts rated; 20 watts peak *Frequency Response:* 10-100,000 c.p.s., within 1dB 15-30,000 c.p.s. *Distortion:* less than 0.1%. *Damping Factor:* 40. *Hum Level:* Better than 80dB down. *NFB:* 3 loop, main overall loop 28dB *Sensitivity:* 8mV (Gram input A) for 10 watts. *Spare Power Supplies:* 320v, 45mA and 6.3v, 2A. *Valves:* Pre-Amp ECC83, EF86. Amplifier GZ34, ECC85, EF86, 2 x EL34's. *Controls:* 1. INPUT—Mic, Radio, Tape, Gram (in conjunction with 4 position pick-up matching selector). 2. EQUALISER—6 position. 3. FILTER—6 position. 4 & 5. BASS & TREBLE (both lift & cut 15dB). 6. VOLUME. *Tape Output Socket* on rear of Control Unit.

Matching VHF Tuner—FM61—£22/1/0.

Sound Value for only £32 complete

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Another "*Winner*" for Garrard

THE HIGH QUALITY R.C.88/4 RECORD CHANGER

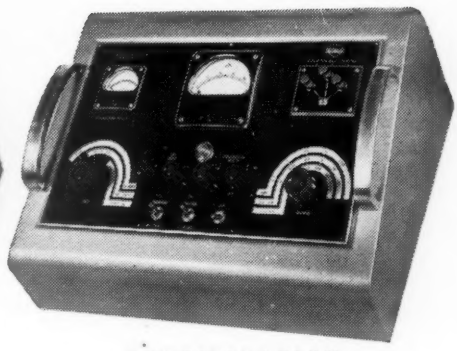
FEATURES : Will play automatically any number of records up to eight of any one of the following types at each loading: 10" or 12" at 78 r.p.m.; 7", 10" or 12" at 33-1/3 r.p.m.; 7" at 45 r.p.m. . . Manual control for playing records singly. . . Supplied with two records spindles, one stepped to play records automatically, the other a short spindle together with a centre hole adaptor for playing records manually. A large record spindle Type LRS3 for playing 7" 45 r.p.m. large centre hole records is available as an optional extra. . . Well proved design of record platform. . . Intermediate Drive Wheel Automatically retracts when changer switches off, also during speed change. . . Automatically switches off when last record has played. . . Adjustment for pickup stylus pressure. . . Aluminium die cast pickup arm incorporating the Garrard plug-in pickup feature, facilitates the choice of a wide range of pickups. . . Fitted with pickup muting switch. . . A.C. Model, dual voltage range 100-130 and 200-250 volts. 50 or 60 cycles according to the size of motor pulley fitted. . . Universal Model R.C.88U, 100-130 and 200-250 volts D.C. and A.C. 25/100 cycles. . . D.C. mains and battery models also available. . . Overall size of record changer 15½" long x 13¼" back to front and 5¾" above and 3⅞" below top of motor board, with Universal or D.C. models an extra depth of 2" is necessary. . . Weight complete, 13 lbs.

An illustrated catalogue of the whole Garrard range is available on request.

Garrard
AUDIO PERFECTION

THE GARRARD ENGINEERING & MANUFACTURING CO. LTD., SWINDON, WILTSHIRE

COMPACT TRANSISTOR TESTER



With the L2642 design engineers can check instantly the characteristics of transistors and establish their working parameters.

- ✳ **Current Gain (α') in grounded emitter connection.**
- ✳ **Collector current ($I'c(0)$) with zero base current.**
- ✳ **Collector turnover voltage**

SPECIFICATION

Current gain (α')	
Ranges	0–100, 0–200 } accuracy ± 7%
Collector voltage	0–30V
Collector Current max.	2.5A at low voltage. 200mA at 30V
Leakage current ($I'c(0)$)	
Collector voltage	0–30V accuracy ± 7%
Collector turnover voltage	
Range	0–80V
Mains input	200–250V 40 to 60 c/s. Consumption approximately 15W.

IMPORTANT NEWS for designers of transistorised equipment

The L280 is the first mains operated power source developed specifically for use with transistors.

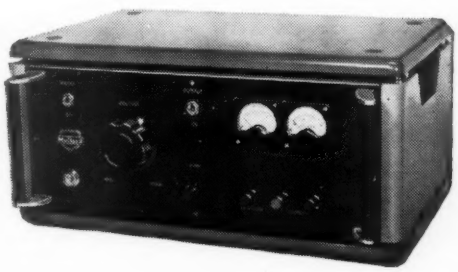
It provides designers with the most convenient source of power for transistors yet developed.

- ✳ **Transistorised—for long life**
- ✳ **Mains operated—obviating battery troubles**
- ✳ **Fully stabilised—against load and input fluctuations**

SPECIFICATION

D.C. output voltage	0–30V continuously variable
Output current	0–1A. Output voltage variations <80mV over complete range
Regulation	< 60mV for mains input fluctuations of ± 10V, < 200mV for ambient temperature fluctuations 20–50°C
Response time	1 millisecond
Output resistance	< 0.08Ω at D.C. < 0.2Ω all frequencies up to 100k/cs
Residual ripple	1mV under worst conditions
Isolation from earth and mains	up to 500V. D.C. Up to 250V. A.C.
Mains input	105, 110V; 200–250V 40 to 60 c/s. Consumption approximately 60W

UNIQUE TRANSISTOR POWER SOURCE



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MULLARD EQUIPMENT LIMITED

Mullard House · Torrington Place
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ME621b
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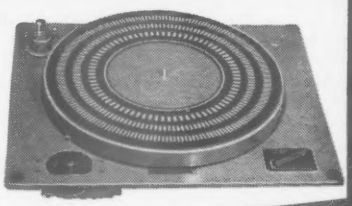
We make no extravagant claims for Connoisseur products, all we ask is that you listen to them and judge for yourself. They are not cheap but then the best never is. Look at the specifications.

Connoisseur Variable 3-speed Gramophone Motor

Mechanical speed change without braking provides 4% variation at all speeds. Synchronous motor is virtually vibrationless. Main spindle runs in phosphor bronze bearings. Turntable is full 12" lathe turned from non-ferrous material.



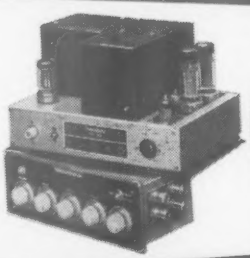
Connoisseur Pick-up

With three interchangeable heads for micro-groove, standard and older records, available with Diamond or Sapphire Stylus.

Frequency range 25-20,000 cps ± 2 dB's, 400 ohms Model gives 15 M.V. output from the average LP disc ; 25 M.V. from a standard 78 rpm recording.

Connoisseur HQ 20 Amplifier and Pre-amplifier

Both units are built to the highest electrical and mechanical standards and incorporate the latest developments in Audio technique. High Power output allows the reproduction of peak passages without overload or distortion.



Connoisseur

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Well Green Lane, Brighouse, Yorkshire. Tel: Brighouse 2397

A. R. SUGDEN & CO (Engineers) LIMITED

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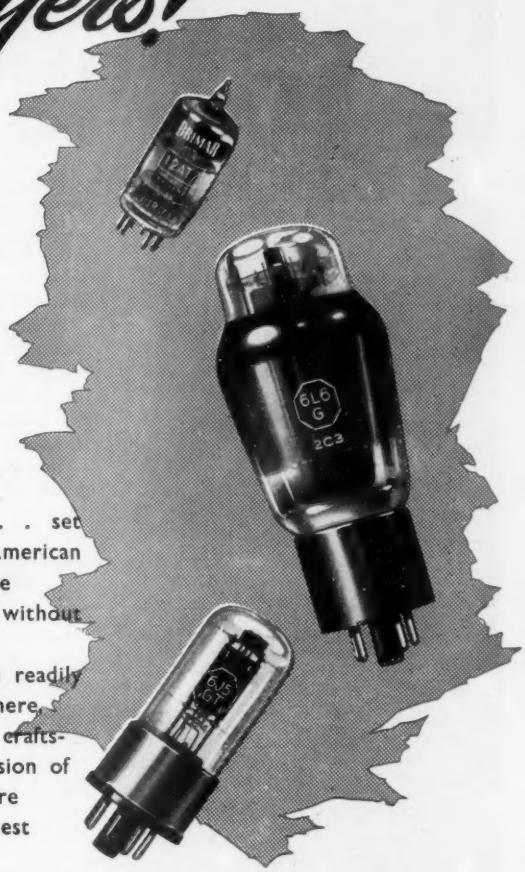
pay STERLING for your American Type Valves



More and more the world's governments . . . set makers . . laboratories are standardizing on American types, valves which are obtainable anywhere in the world, valves which you can get from BRIMAR without expending dollars.

BRIMAR valves are readily available everywhere, and with their craftsmanship, precision of manufacture, are amongst the finest obtainable.

Efficient . . . reliable . . . robust . . . BRIMAR VALVES are chosen for radio and electronic equipments in the fighting services and throughout industry. Their rugged dependability can contribute so much to your own products.

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Dependable

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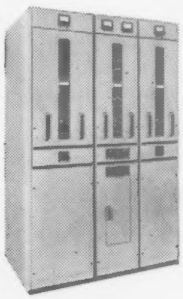
Standard Telephones and Cables Limited FOOTSCRAY, SIDCUP, KENT, ENGLAND.

2·3 kW channelised transmitter

The versatility and reliability of this new, tropicalised transmitter make it eminently suitable for h.f. en-route, ground-to-air services and point-to-point communication networks. The GFT.560/2 is of unit construction and consists of three basic cabinets—r.f. unit, modulator unit and power supply units—which can be used in combination for multi-frequency working and a number of types of emission. There are ancillary units available that permit remote control of the transmitter over telephone circuits.

*

Frequency Range 1.5 to 30 Mc/s.
Frequency Stability to Atlantic City 1947 standards.
Power Output 3kW. c.w., 2kW. m.c.w. or r/t.
Types of Emission, c.w., m.c.w., telephony, frequency shift (with external keying unit), A1, A2, A3, F1.
Output Impedance 600 ohms balanced.
Power Supply 400V. 50-60 c/s 3-phase.



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ME592a

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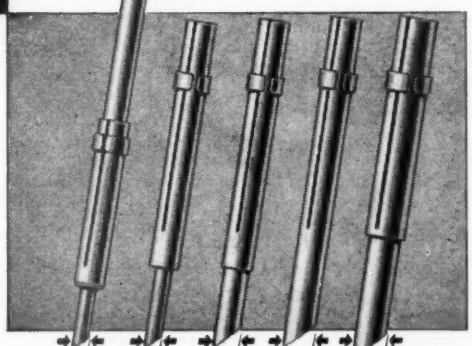
..... from 6 to 240 volts.

No transformer needed for the pencil-sized 'PRECISION' soldering iron. Model C.240 works direct off the mains and is fitted with 3-core lead. Flash tested at 900 volts A.C. The interchangeable bits (4 sizes to fit model C.240) are easy to remove, even after many weeks of soldering. All models have insulated elements and are eminently suitable for transistor work.

full size

Precision

MODEL	VOLTAGE	WATTAGE	STANDARD BIT	ALTERNATIVE BIT
A. 6	6	8	1	Nil
A. 12	12-13	8	1	,,
A. 24	22-26	8	1	,,
A. 28	26-30	8	1	,,
B. 6	6	12	4	2 or 3
B. 12	12-13	12	4	2 or 3
B. 24	22-26	12	4	2 or 3
B. 28	26-30	12	4	2 or 3
C. 50	48-52	15	4	2, 3 or 5
C. 115	110-120	15	4	2, 3 or 5
C. 125	120-130	15	4	2, 3 or 5
C. 220	210-230	15	4	2, 3 or 5
C. 240	230-240	15	4	2, 3 or 5



3/32" 2.4 mm	3/32" 2.4 mm	5/32" 4.0 mm	3.16" + 4.8 mm	3.16" Heavy 4.8 mm Duty
No.1	**No.2**	**No.3**	**No.4**	**No.5**

- Complete weight less than one ounce.
- Non-slip handle with thermal airgap.
- Replaceable bits are heavily nickel plated.
- Short shaft and correct balance give precise control.
- Highly flexible light-weight lead, easily replaceable.
- Clamp on lead removes all strain from connections.
- Fully insulated elements ensure complete protection.
- Complete safety provided by earth connection and rigorous testing.
- Replaceable elements sealed in shock absorber mounting for reliability.

Transformers available

Model LV6	Input 230/250V.	Output 6V.
Model LV12	Input 230/250V.	Output 12 & 24V.

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XUM

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Condenser Specialists for over 20 years.

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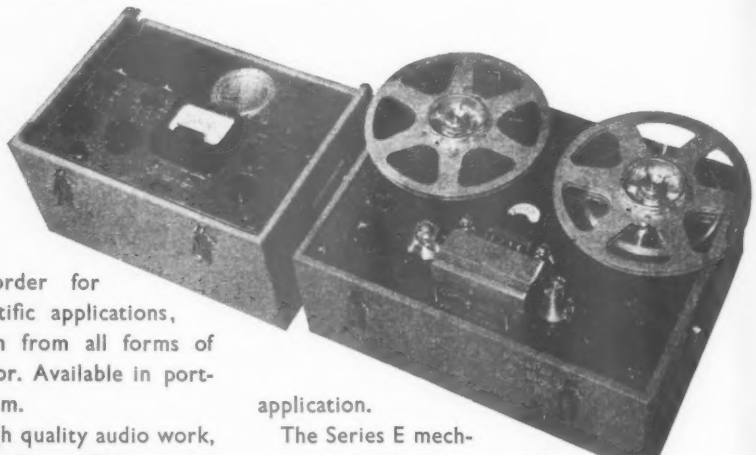
LEEVERS RICH

MAGNETIC TAPE RECORDER SERIES E



An A.C. operated heavy-duty magnetic tape recorder for studio, industrial and scientific applications, where the utmost freedom from all forms of signal distortion is called for. Available in portable or rack-mounting form.

Standard models for high quality audio work, such as master recordings, radio and TV material. **Special versions** for such purposes as recording ultra-sonic phenomena, stereo recording, and multi-channel instrumentation. A plug-in amplifier system is available covering a wide field of application.

The Series E mechanism embodies a two-speed synchronous motor capstan drive as standard, but will accommodate alternative capstan units of the servo type, giving wide speed range or extreme accuracy of linear speed over long periods.

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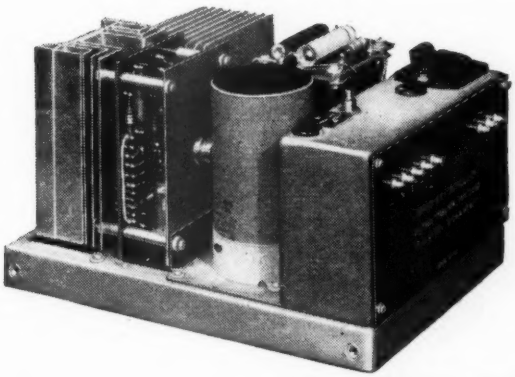
78B Hampstead Road, London, N.W. 1 EUSton 1481

The 1st. variable voltage Transistorised power unit at a reasonable price – £39

In the DC.65, SERVOMEX production techniques combine with semi-conductor circuits to give a faster control and a lower price. This unobjectionable result is described in data sheet DC.65 obtainable on request.

- *Output 6-14 volts, 0-1 Amp.*
- *Stabilisation factor 600.*
- *Output resistance $< 15m\Omega$.*
- *Response time $< 100\mu S$.*

Price £39 delivered in U.K.



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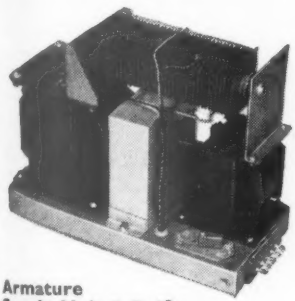
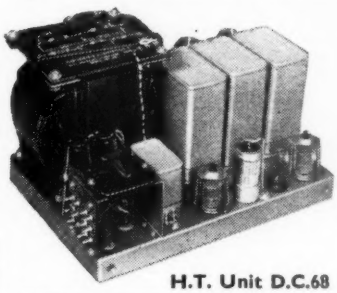
With the aid of these three basic Servomex units, servo-control systems can be assembled by the user to meet his own specialised requirements.



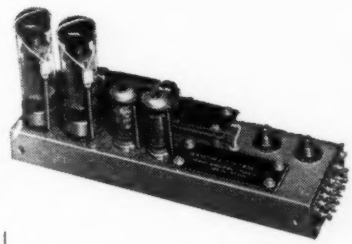
Armature Supply Unit A.S. 69

High impedance source for feeding the armature of D.C. Servo motors using the " constant current " technique. Nominal output 0.48 or 0.35 amps. Suitable for 105–250 volts A.C., 45–65 c/s.



H.T. Unit D.C.68

A general purpose anode and heater supply unit giving 250–350 volts D.C. at 0–150mA and 85 volts D.C. for a voltage reference, both highly stabilised. Three unstabilised 6.3 volts A.C. outputs. For 105 to 250 volts A.C., 45/65 c/s.



Servo Amplifier S.A.61

High gain D.C. amplifier for driving standard 80 mA field windings. Can be powered by D.C. 68 or any other conventional H.T. unit. Balanced circuit throughout to reduce drift. Gain 2 amperes per volt.

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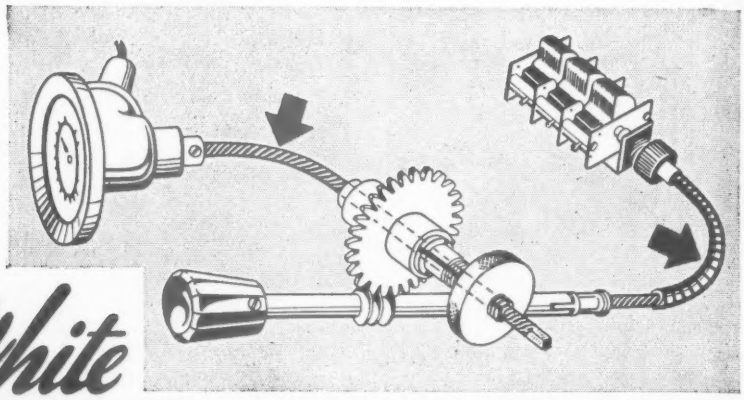

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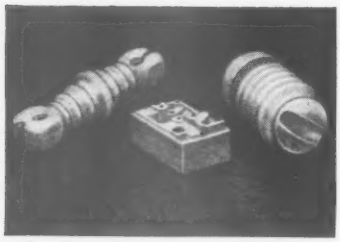

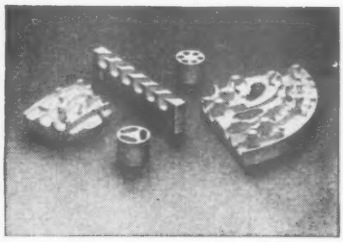

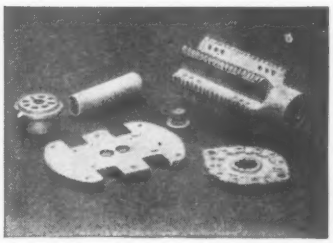

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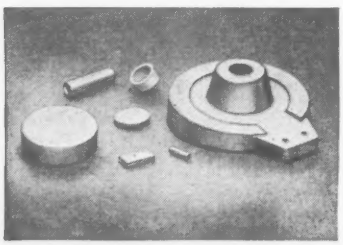

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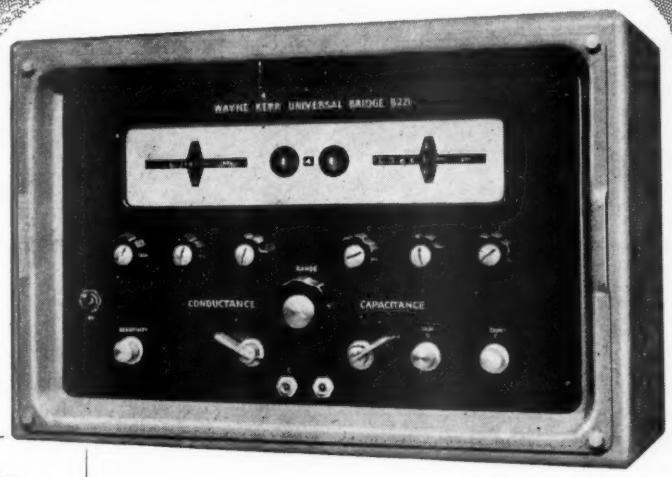
WAYNE KERR UNIVERSAL BRIDGE B.221



Specification

BRIDGE ONLY:
Capacitance: 0.0002 pF to 10 μF in 7 ranges. Accuracy $\pm 1\%$. Conductance: 0-$\pm$ 100 mmho in 7 ranges. Inductance: 1mH to infinity in 7 ranges. Measuring Frequency: 10,000 radians/sec. (1592 c/s.) Power Supply: 110/115 and 200/250 V 40/60 c/s. Dimensions: 17" x 7" x 11½" high. Weight: 25 lbs. approx.

WITH LOW IMPEDANCE ADAPTOR:
Capacitance: 1μF—100,000μF in 4 ranges. Resistance: 0-100Ω in 4 ranges: Discrimination on lowest range 50$\mu\Omega$. Inductance: 0-10 mH in 4 ranges. Discrimination on lowest range 5mμH.

PRICES:
Bridge, £200. Low Impedance Adaptor £25

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● *Accuracy to 0.25% is achieved with complete stability.* ● *Two decades and a continuously variable control indicate independently the resistive and reactive terms to four significant figures.* ● *Adaptors for measurement of conductivity, dielectric constant and loss factor of solids and liquids.*

The B.221 is a highly accurate transformer ratio arm bridge of very advanced design. It provides facilities for the two, three, or four-terminal measurement of impedance or transfer admittance over an extremely wide range at an operating frequency of 10,000 radians/sec. (1592 c/s).

Measurement is unaffected by the impedance of the test leads, which can therefore be of any length. Consequently the instrument is ideally suitable for the determination of temperature coefficient of components under test conditions or, in fact, any remote in situ measurement. A novel mechanism automatically displays the cyphers, decimals and units of measurement. This gives direct reading and avoids any confusion which might be caused by the large multiplying factors involved.

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A small portable instrument designed for the simple and direct measurement of inductance values between 0.05 μH and 100mH. Price £65.

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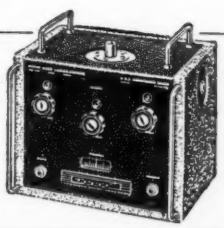

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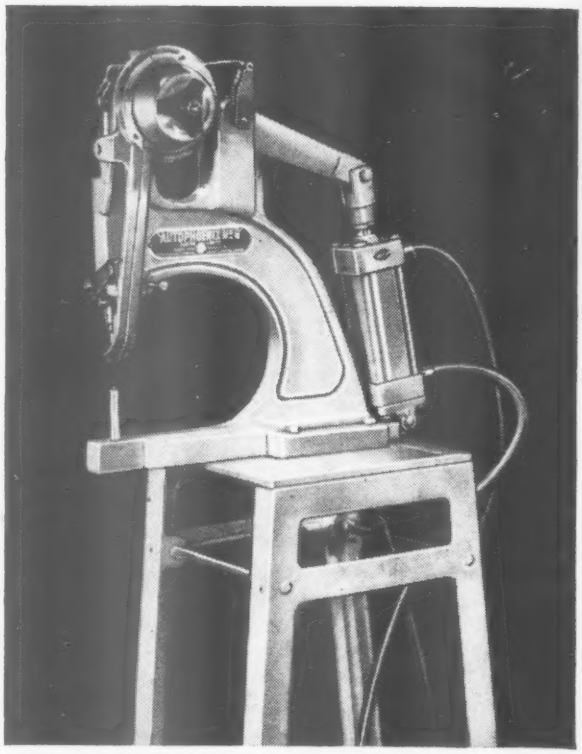

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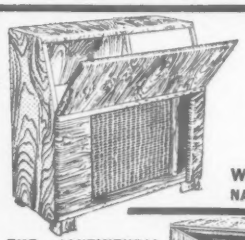

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This popular bureau cabinet is veneered with the finest selected Walnut and beautifully polished in a medium shade. Designed to accommodate almost any of the many units we have available and to give generous storage compartments.

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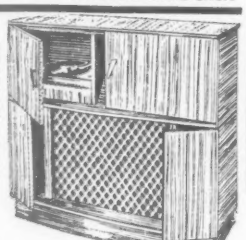

THE CONTINENTAL

This elegant Cabinet is the latest in our range designed in the continental style, solidly constructed and finished in selected mahogany veneers. Available medium, light, high gloss or contemporary finish

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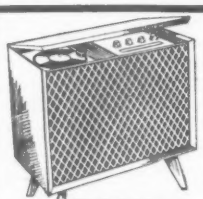

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This beautifully made cabinet is oak veneered with mahogany interior and is waxed finished. Available in any shade to order at slightly extra cost.

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The unit also accommodates any type of amplifier, plus most radio tuners.

9 gns.
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See Page 80

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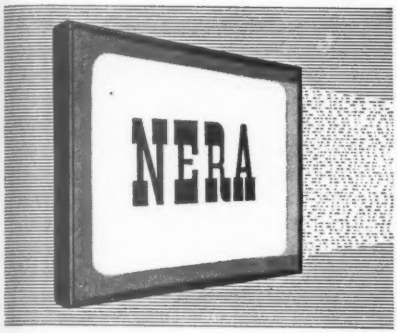

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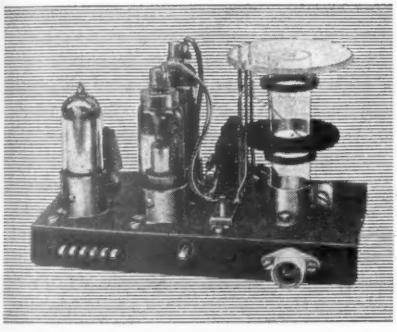

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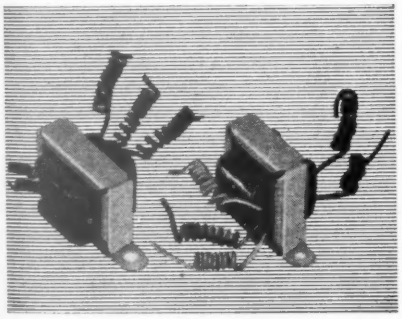

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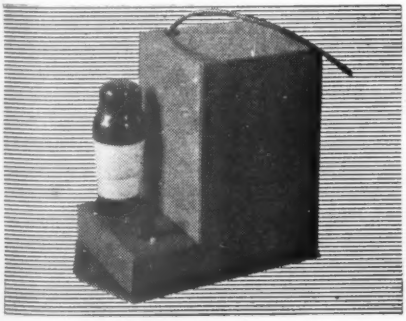

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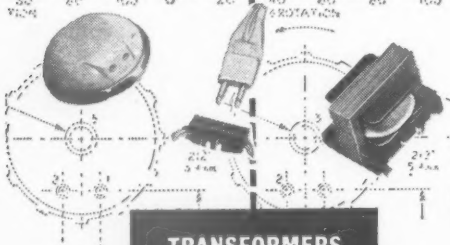

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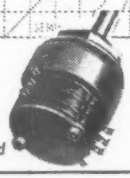

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The comparative simplicity of associated circuitry, combined with the low cost of the tube itself, recommend the 3AFP1 for a wide variety of applications.

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The 3AFP1 is suitable for symmetrical or asymmetrical operation.

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Vh = 6.3V Ih = 0.55A

Typical Operation

Va1+a3	1000V
Va2	210 to 320V
Vg	−28 to −65V
Sx	20V/cm
Sy	11.5V/cm

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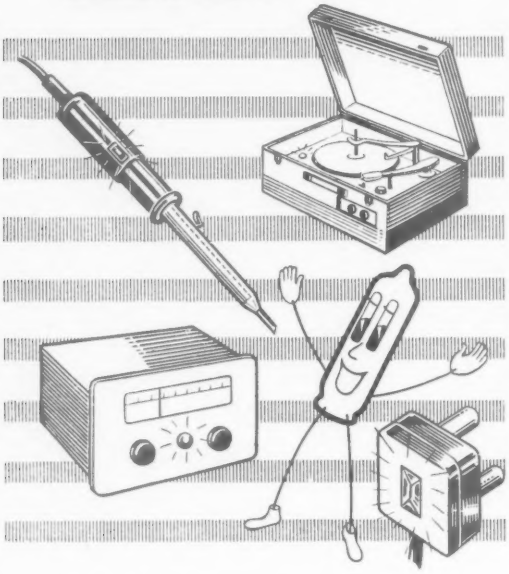
ETL 4a

For better indication fit a Hivac neon



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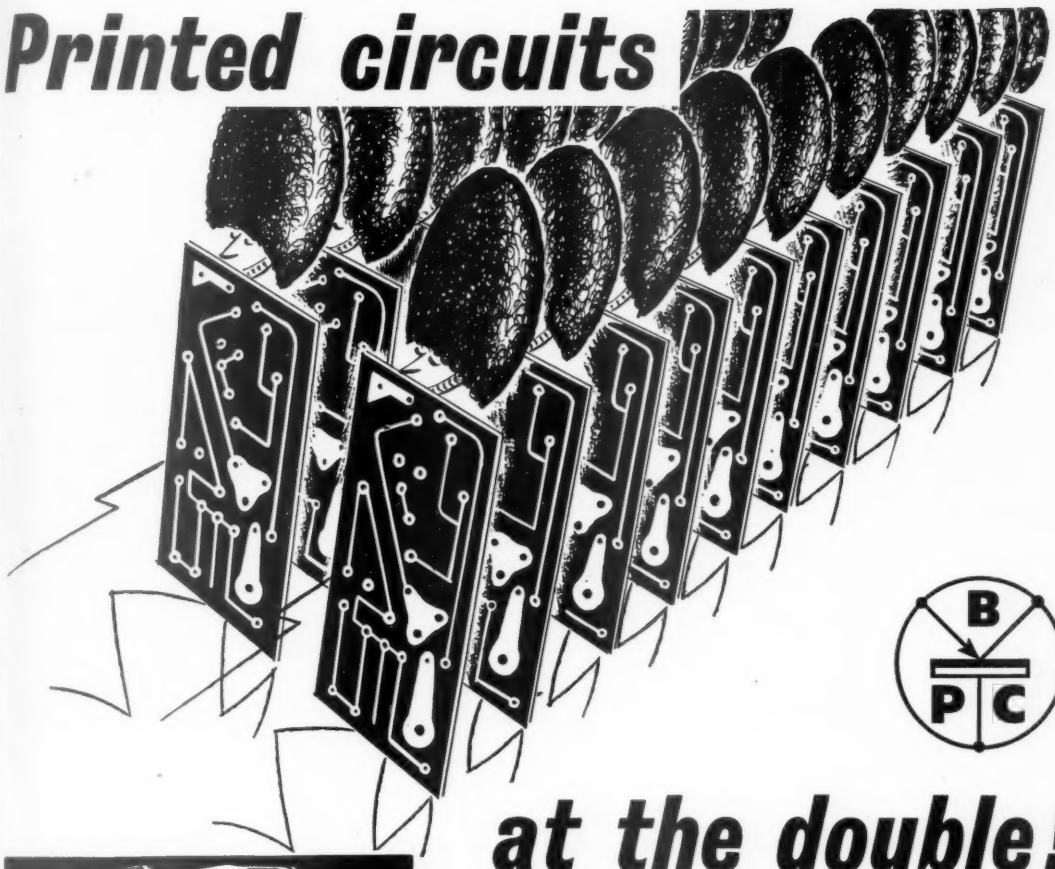

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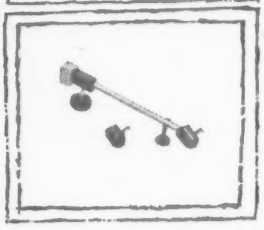

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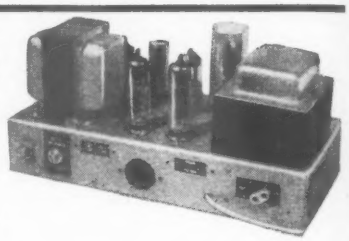

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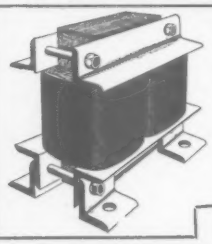

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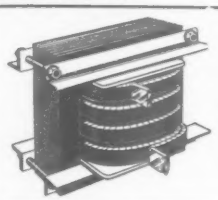

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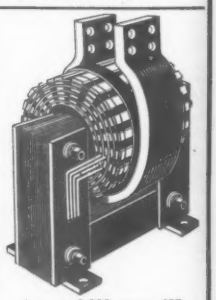

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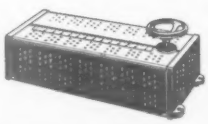

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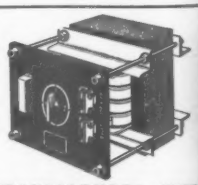

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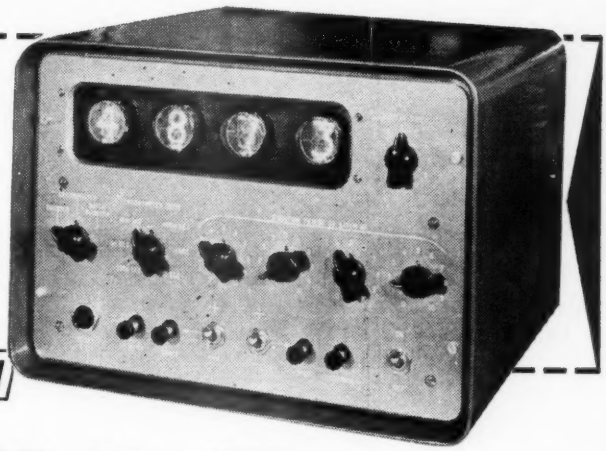

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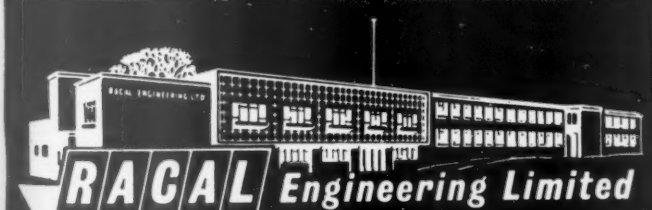

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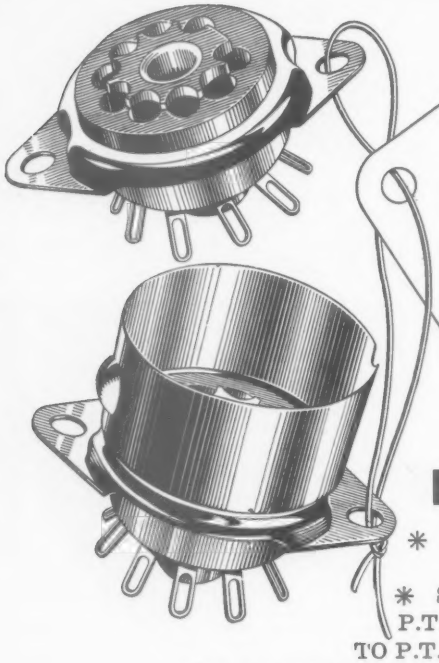

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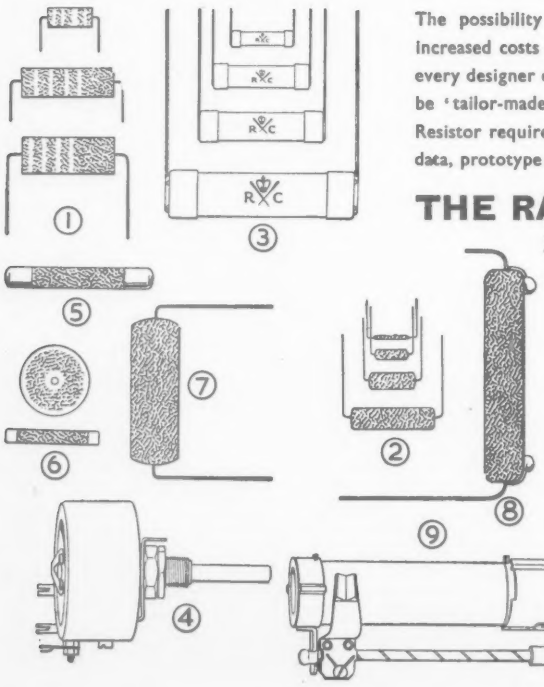

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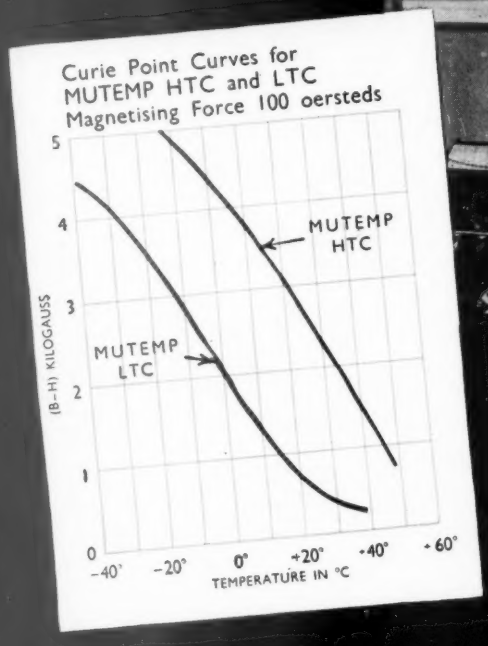
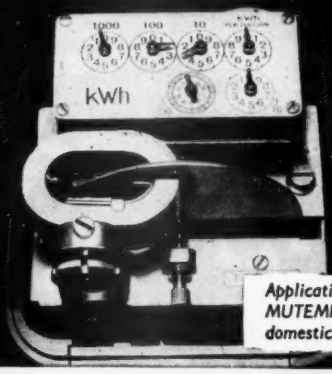


Measurement of the change in characteristics with temperature.



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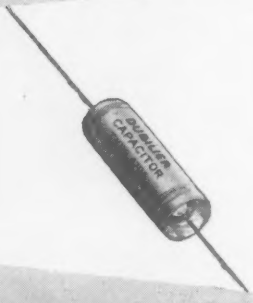

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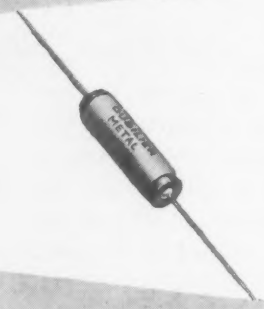

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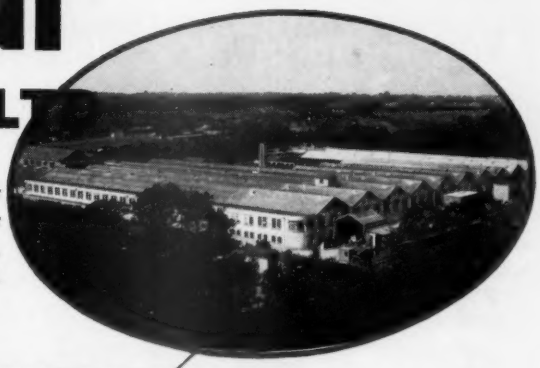

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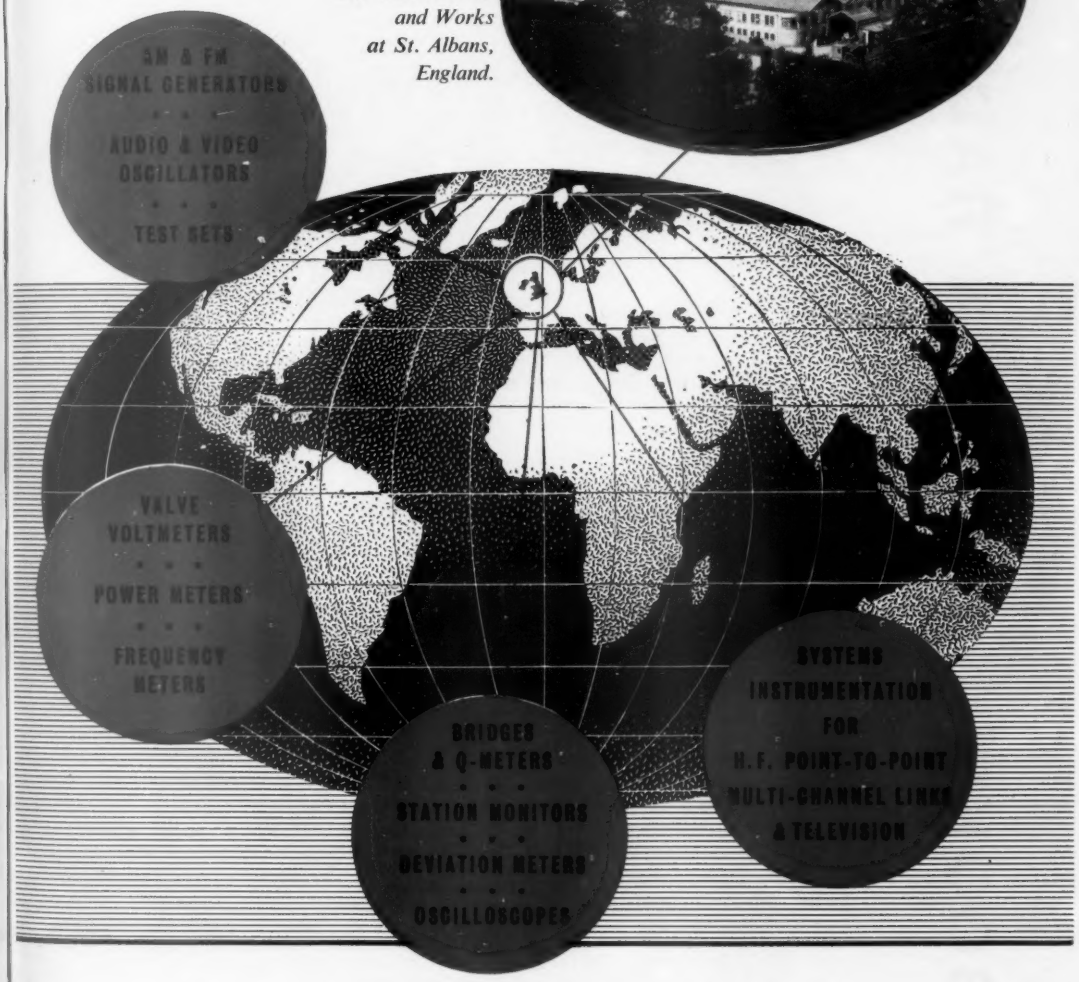

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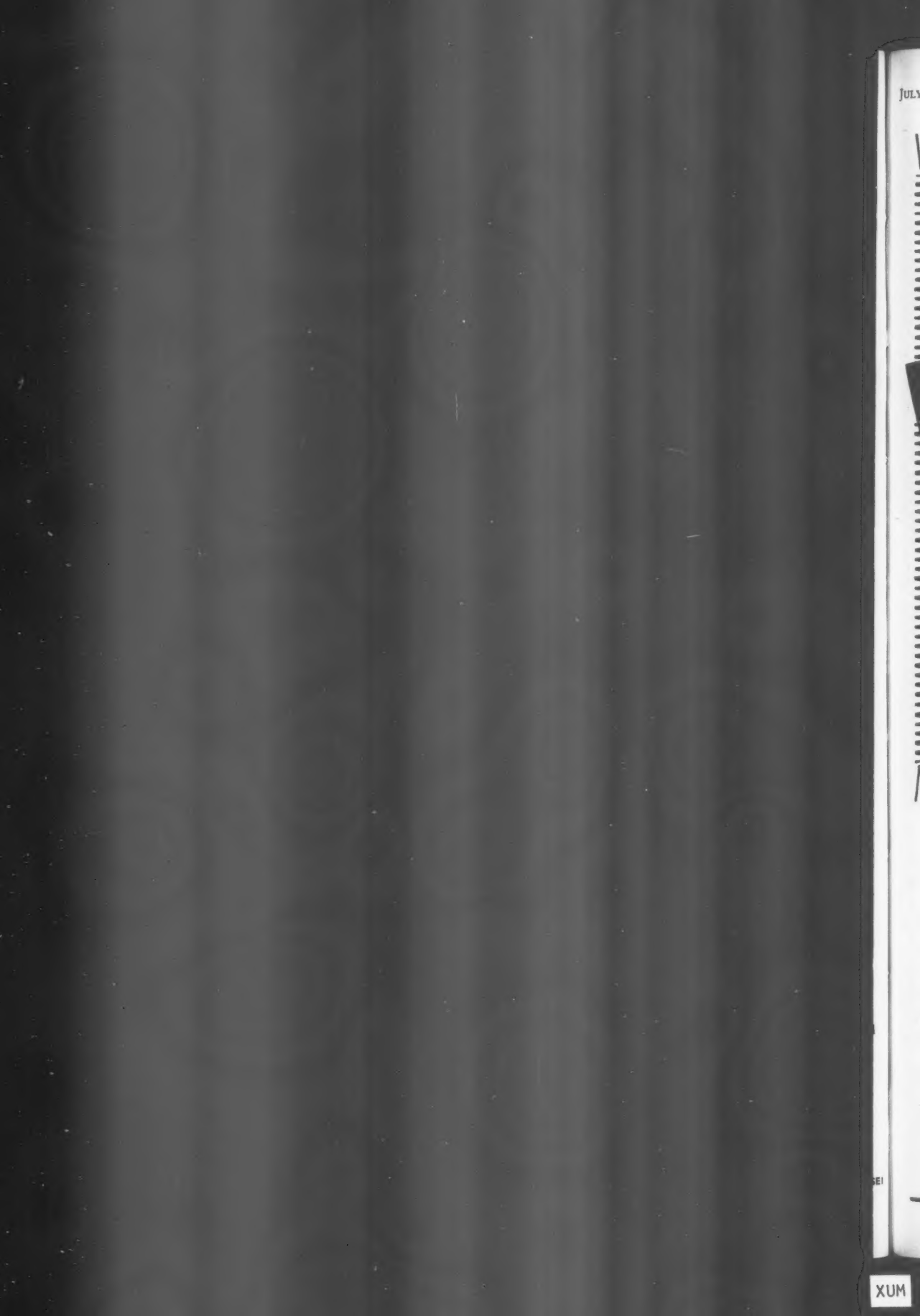

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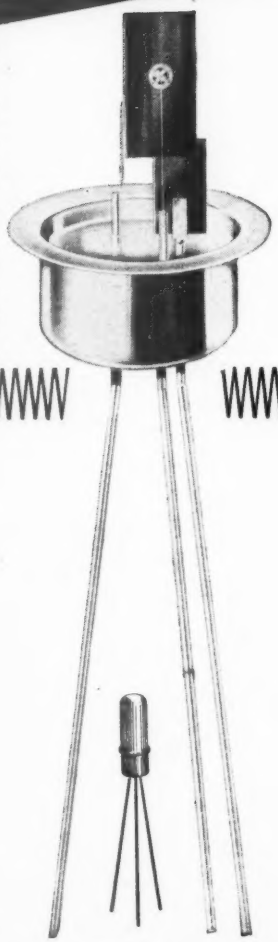

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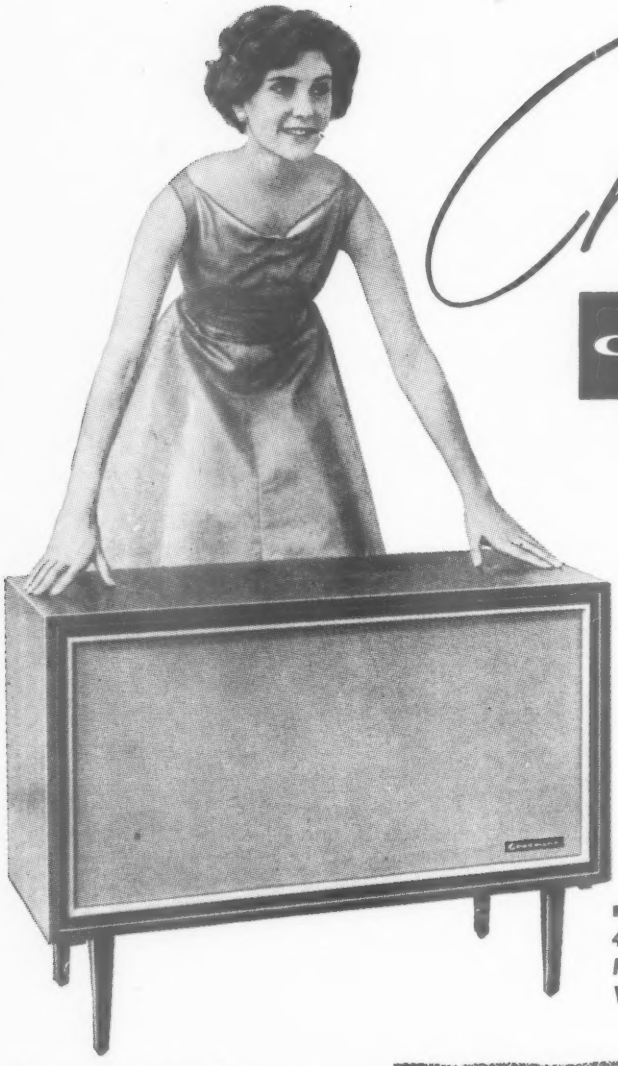

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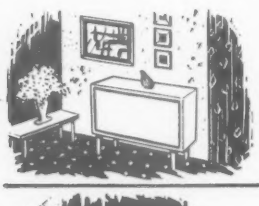
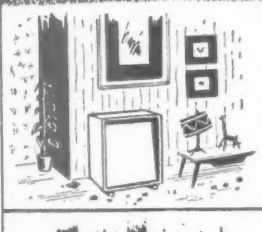


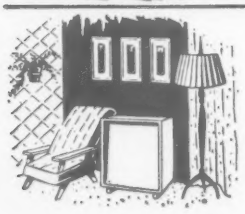
MODEL 15/4 *(Illustrated)*

This 4-way quadruple radiator Full-range High Fidelity Loudspeaker System is characterised by exceptional smoothness. Entirely new Enclosure design, wax polished in selected Walnut veneers.



SHERWOOD 1

A balanced 2-Radiator SINGLE Unit Full-Range High Fidelity System. The Enclosure is wax polished in selected Walnut veneers.



SHERWOOD 2

The SHERWOOD 2 is a balanced 3-Radiator Twin Unit Full-Range High Fidelity System, Enclosure as SHERWOOD 1.

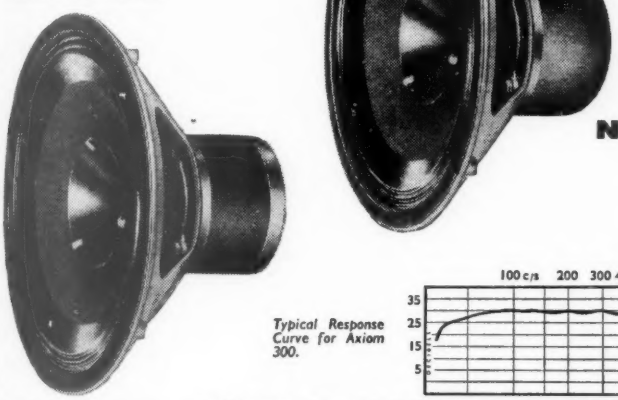
SHERWOOD 3

Balanced 3-way Full-Range, 30 c/s to 16,000 c/s, High Fidelity Loudspeaker System in Sherwood Enclosure. Overall range divided between three specially developed precision built units.

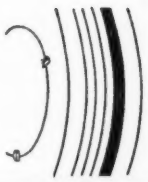
Fidelity

Axiom 300

Axiom 400

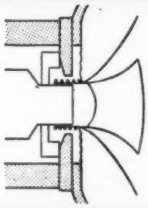


NEW



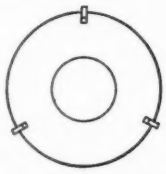
PLASTIC TREATED BASS DIAPHRAGM SUSPENSION provides correct termination to eliminate standing waves and edge resonances.

NEW



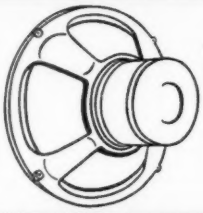
LONG ALUMINIUM VOICE COIL combines low mass for extended high frequency operation with constant "turns in the gap" at high bass amplitude.

NEW

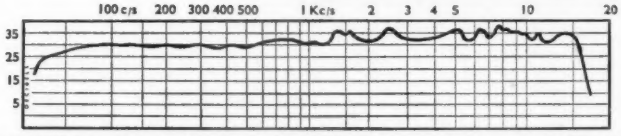


FOAM TERMINATED TWEETER CONE for prevention of spurious resonances.

NEW

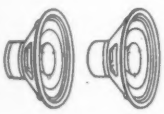


CHASSIS DESIGN gives maximum open area combined with immense rigidity and freedom from ringing.

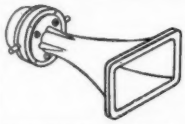


Typical Response Curve for Axiom 300.

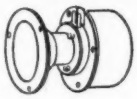
With these features . . .



UNDISTORTED BASS
Superb transient response, achieved by use of powerful magnets, correct loading, and precisely controlled low resonance with plastic suspension.

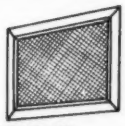


UNDISTORTED MID-RANGE
Achieved by all FOUR Systems. In Sherwood 1 and 2 by mechanical crossover and Auxiliary Diaphragm; in Sherwood 3 and the 15/4 by electrical crossovers in conjunction with latest Mid-Range pressure driven Horn Loaded Unit.



UNDISTORTED TREBLE
Cleanly radiated high notes, by virtue of newly developed twin cone design in Sherwood 1. Sherwood 2 and 3 both employ tailored High Frequency Pressure Driven Horn loaded units. The new 15/4 system utilizes two such units positioned to give maximum coverage.

MULTI-RADIATOR SYSTEM
All Enclosures and Units designed to give lowest distortion full range reproduction.



COMPACT SIZE
Achieved by exclusive patented A.R.U. design. No other system gives such efficiency in relation to size.

Free on request: 1958 HIGH FIDELITY LOUDSPEAKER MANUAL. Fully describes all Goodmans High Fidelity Products.

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GOODMANS INDUSTRIES, LIMITED,
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WEMbley 1200 (8 lines) Grams: Goodaxiom, Wembley, England.

Aspects of design

1

VISION I.F. AMPLIFIERS (Part 1)

This is the first of a series of special features dealing with advanced problems in television and radio circuit design to be published by Siemens Edison Swan. The Ediswan Mazda Applications Laboratory will be pleased to deal with any questions arising from this, or future articles, the second of which will appear in the August issue.

The relatively wide band requirements of a vision I.F. amplifier necessitate the use of low impedance circuits in each stage. The gain of a stage (G) using a pentode valve is given by $G \simeq gm\, Z_L$ and if the bandwidth is taken at the points where the response is 3 dB down, the stage gain for the case of an inter-stage coupling consisting of coupled double tuned circuits is.—

$$G = \frac{1}{B} \times \frac{gm \times 10^3}{2\pi\sqrt{C_{in}\, C_{out}}}$$

where G = stage gain
B = bandwidth at 3 dB points (Mc/s)
gm = mutual conductance of the valve (mA/V)
C_{in} = valve input capacitance (pF)
C_{out} = valve output capacitance (pF)

As the bandwidth is fixed by the requirements of the amplifier then in order to obtain an economic gain per stage the mutual conductance must be made high while the input and output capacitances are kept low. In valve design these are usually conflicting requirements and a number of factors have to be considered in deciding the best way to meet them.

FIGURE OF MERIT

The relationship between the mutual conductance, the valve capacitance and the gain-bandwidth product follows from the above formula so that:—

$$G \times B = \frac{gm \times 10^3}{2\pi\sqrt{C_{in}\, C_{out}}} = \text{Mc/s}$$

This is also known as the figure of merit of the valve and it might be thought that the choice of the most suitable valve would go to the one having the highest figure of merit.

But this is really only half the story for the valve capacitances are only part of the total circuit capacitances; the other part being made up of a number of separate capacitances consisting of the valveholder, coil distributed capacitances and the damping resistor. Even in the best designed layout these can total to a value comparable to the output capacitance of the valve itself.

DESIGN OF VISION I.F. AMPLIFIERS

The effect of these stray capacitances on the figure of merit when applied to the actual amplifier stage is to degrade its value by a factor which may be called the capacitance degradation factor (C.D.F.) defined as the ratio of the valve capacitance to the apparent overall circuit capacitance.

For a double tuned circuit this factor is expressed as:—

$$\text{C.D.F.} = \frac{\sqrt{C_{in} \times C_{out}}}{\sqrt{(C_{in} + \text{Strays})\,(C_{out} + \text{Strays})}}$$

and the effective figure of merit of the circuit is therefore given as

(Figure of merit of the valve) × (C.D.F.)

As the circuit strays can be regarded as reasonably constant it can be seen that the factor, usually not much higher than 0.6, will be lower for valves with low input and output capacitances and it will approach unity as the input and output capacitances of the valve go up. So that the attendant increase of valve capacitance that occurs with an increase in mutual conductance is not such a serious drawback as might have been expected when it is considered in conjunction with the total circuit capacitance.

It is clear then that the figure of merit for the valve alone cannot be taken as a means of assessing its relative performance in terms of Gain-Bandwidth product; the only true comparison must include the degrading effects of stray capacitance.

It is for this reason that for many years now the Ediswan Mazda range of Television R.F. pentodes has been designed on the basis of making valves with a high value of mutual conductance even if this results in some increase in the input and output capacitance, for by following this technique the effective figure of merit per stage can be kept at its highest value and when spread over say three stages this results in an appreciable improvement in the Gain-Bandwidth product of the amplifier.

Another way in which the design of the valve can help in providing the highest overall figure of merit concerns the output or anode-to-earth capacitance.

For a double tuned circuit the figure of merit is inversely proportional to $\sqrt{C_{in} \times C_{out}}$ and since C_{out} is always considerably lower than C_{in} any reduction of C_{out} whether in the valve or as "strays" will bring about a much greater improvement in the figure of merit than if the same reduction were made to the input circuit. In the Ediswan Mazda range of Television R.F. Pentodes the design of the anode structure is always made as small as possible, consistent with adequate heat dissipation. This results in the lowest value of output capacitance and affords the greatest assistance to the circuit designer when used in an external anode circuit where the "strays" have been reduced to a minimum.

FIGURE OF MERIT FOR A TYPICAL CIRCUIT USING THE 30F5

30F5		*"STRAYS"*	
Input capacitance	9.0 pF*	Valveholder	1.3 pF
Output capacitance	4.4 pF	Self capacitance of coil in can, including lead	2.1 pF
		Damping resistor	0.2 pF
		Total strays	3.6 pF

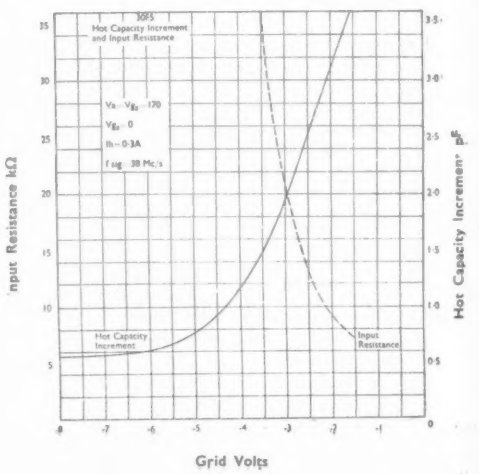
*The electron stream increases the input capacitance as shown in Figure 1. Typical increment at operating point is 3.2 pF.

Figure of Merit for Valve only $= \dfrac{8.8 \times 10^3}{6.28\sqrt{12.2 \times 4.4}} = 191$ Mc/s

Capacitance degradation Factor $= \dfrac{\sqrt{12.2 \times 4.4}}{\sqrt{(12.2 + 3.6)\,(4.4 + 3.6)}} = 0.65$

∴ Effective Figure of Merit = 191 Mc/s × 0.65 = 124 Mc/s.

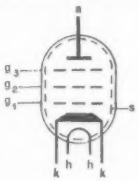
FIG. 1

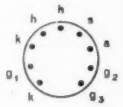


EDISWAN MAZDA 30F5

Screened R.F. Pentode for a.c./d.c. mains Television Receivers

Heater volts	7.3
Heater current	0.3 amps
Maximum anode watts	3.0
Maximum screen watts	1.0





CAPACITANCES

g_1 to E	9.0 pF
a to E	4.4 pF
g_1 to a	0.0073 pF

TYPICAL OPERATION

Anode volts	170
Screen volts	170
Grid bias volts	1.9
Anode current (mA)	10
Screen curren (mA)	2.6
Mutal conductance (mA/V)	8.8
Self bias resistance (ohms)	150
Equivalent grid noise resistance (ohms)	750
Input loss at 45 Mc/s (ohms) (with grid circuit returned to pin 3)	16,000
Input loss at 38 Mc/s (ohms) (with cathodes strapped)	8,800

If you are a T.V. equipment manufacturer we shall be pleased to supply full technical details of our "First Preference" range of 0.3 amp. heater type valves, together with a set of valves for testing on receipt of your enquiry.

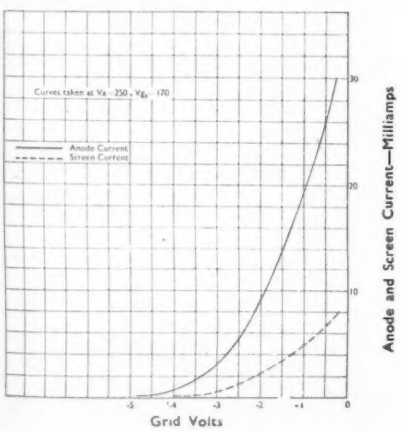
APPLICATION USES OF THE 30F5

(a) VISION AND SOUND I.F. AMPLIFIER

The high mutual conductance of the 30F5 resulting in a favourable effective figure of merit makes it eminently suitable as a wide band vision I.F. amplifier while its good stability and high input resistance meet the requirements of a high gain sound I.F. amplifier.

(b) VIDEO AMPLIFIER

The features of the 30F5 which make it very suitable as a video amplifier are to be found in the high value of anode current obtainable with a screen voltage of no more than 170 volts. Thus a large available output voltage swing can be obtained with a low value of anode load resistor.



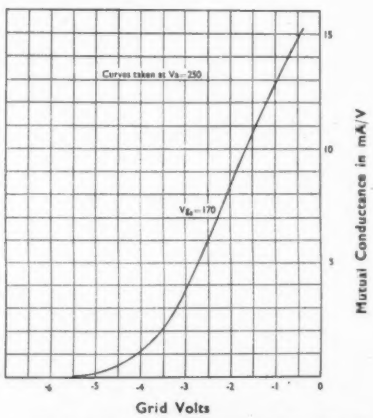
(c) SYNCHRONISING PULSE SEPARATOR

The short grid base of the 30F5 at screen voltages up to 100 V. results in satisfactory separation of synchronising pulses down to low levels of video signal. With an anode resistance of 47 kΩ or greater the rapid rise of anode current from cut-off to maximum also gives good limiting of noise and interference pulses superimposed on the synchronising signal.

(d) SCANNING DRIVE GENERATOR

The 30F5 is useful as a generator of drive voltages for line and frame scanning circuits in cases where it is desirable to isolate the output stage from the synchronising and oscillating circuits. The screen and control grids may be connected in a blocking oscillator circuit to switch the discharge in the anode circuit.

Average Characteristics of Ediswan Mazda Valve Type 30F5



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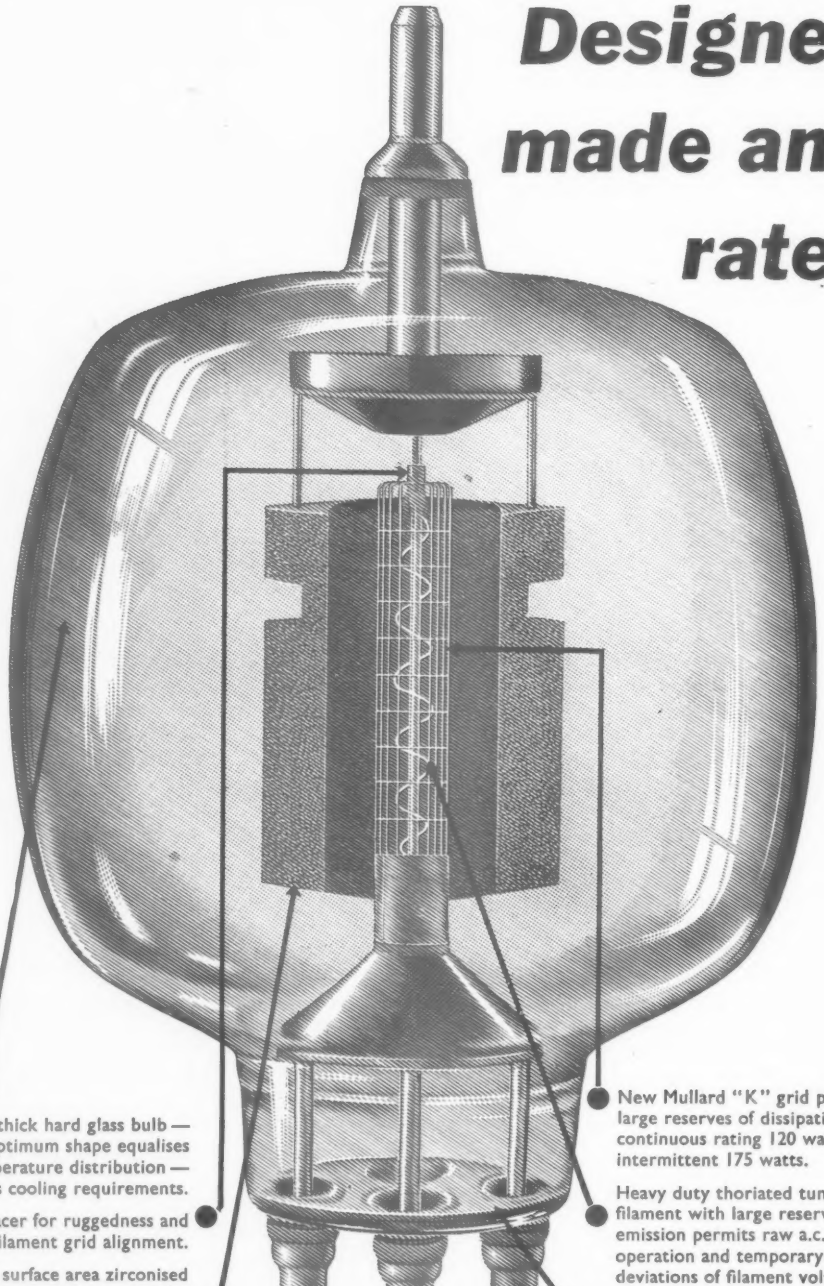
EDISWAN
MAZDA

CRC15/19

Designed made and rated



Extra thick hard glass bulb — optimum shape equalises temperature distribution — cuts cooling requirements.

Silica spacer for ruggedness and accurate filament grid alignment.

Large surface area zirconised carbon anode — rated for continuous dissipation of 800 watts—intermittent rating 1.5 kilowatts.

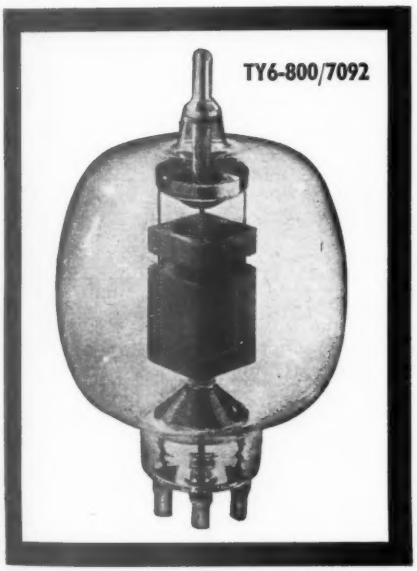
New Mullard "K" grid provides large reserves of dissipation— continuous rating 120 watts, intermittent 175 watts.

Heavy duty thoriated tungsten filament with large reserves of emission permits raw a.c. operation and temporary deviations of filament voltage of + 5% – 10%.

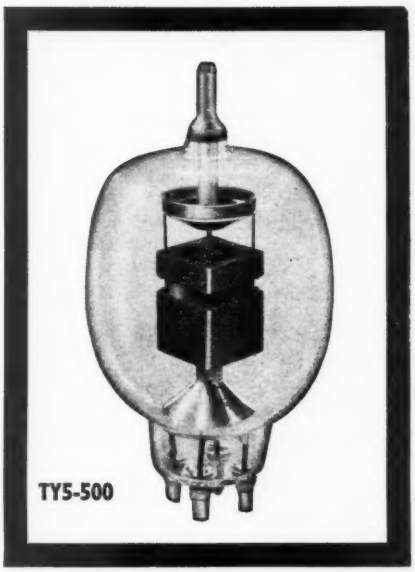
Special base eliminates need for forced air cooling.

FROM THEIR VERY FIRST CONCEPTION these two new Mullard triodes, the TY6-800 and TY5-500, have been specifically designed for use in industrial R.F. heaters. They are rated with generous reserves of anode dissipation, grid dissipation and filament emission to accommodate the variations encountered in industrial R.F. heater operation. Their construction is fundamentally rugged and they are designed for easy and simple cooling. Write to the address below for full details of Mullard industrial valves for R.F. heating.

...for industrial R.F. heaters



For 2kW equipment. Features of this new valve are described on the opposite page.



For 1kW equipment. Same new type of construction as the TY6-800. Supersedes communications types such as 833A.

Mullard

GOVERNMENT AND INDUSTRIAL VALVE DIVISION

Mullard

MULLARD LIMITED
MULLARD HOUSE
TORRINGTON PLACE
LONDON · W.C.1
TEL: LANGHAM 6633

Typical Industrial Oscillator Operation

Type No.	Vf(V)	If (A)	Va (kV)	Ia (mA)	P load (kW)	f (Mc/s)
TY6-800/ 7092	6.3 +5-10%	32	5.0	700	2.3	50
TY5-500	5.0 +5-10%	32.5	4.0	535	1.4	50

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RUNNING TIME METERS with cyclometer dial. Very limited offer of Salford synch. 200/250 v. 50 c., continuously indicating up to 9,999 minutes, with 6 second indication, **£3/10/-** (des. 2/-). Also Sangamo indicating up to 9,999 hours, with 6 min. indication, **£5 5/-** (des. 2/-).
INDUSTRIAL EXTRACTOR FANS, powered with totally enclosed E.E. Co., 1/10th H.P. Motor, 220/250 v. 50 c. 1 ph. (induction), in circular mounting frame 22 inches dia. with 15in. 6-bladed impeller, ball-bearing, silent running, brand new first-class units, **£11/17/6** (des. U.K. 7/6).
SHADED POLE MOTORS (for very silent running) B.T.H. type BP.1304, supplied with 6in. double-bladed fan. Ideal for fan heaters, **39/6** (des. 2/6). Also Delco super model, fan cooled, body 4½ by 3½in., shaft proj. 1¼in., 1,425 r.p.m., torque 600 grm/cms, and perfect for tape recorders, stirrers, cooling fans, extractors, etc. **42/6** (des. 2/6). Also Met-Vick, 1,200 r.p.m., with mounting flange for vertical or horizontal use, **27/6** (des. 2/-). All of the foregoing are for 200/250 v. A.C. and cause no electrostatic interference.
SYNCHRONOUS TIMER MOTORS, 200/250 v. 50 c. Compact units 2½ × 1½ × 1⅝in. with 1in. shaft proj. Self-starting, high torque, 6 r.p.m. Suitable also for display turntables, **57/6** (des. 1/6). Also Sangamo 8.7 units, 200/250 v. 50 c. (synch.) self-starting. Final speeds available from stock: 1 r.p.m., 1 r.p.h. and 12 r.p.h., any one **37/6** (des. 1/6).
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EXTRACTOR FANS. Our huge sales of these confirm that this is the best offer being made of such units. Same high quality, same low price which has been maintained for the past ten years. 200/250 v. A.C., induction motor, silent running, no interference. With mounting frame and back grille, ready for easy installation, with 8in. impeller, 12,000 c.ft./hr. **£5/5/-**, with 10in. impeller, 15,000 c.ft./hr. **£5/12/6** (des. either 2/6).
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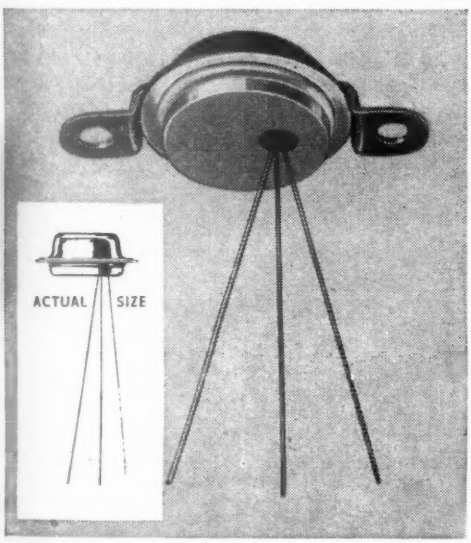

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The Newmarket Transistor Company, first to make RF transistors in Britain on a commercial scale and first again with power types, now introduces a new intermediate power transistor which fills the gap between the general purpose audio and 10-Watt power types.

Perfectly sealed by a cold welding process, this new unit has a special clip mounting which eliminates large fixing studs. Maximum power dissipation is obtained with the unit on a heat sink but a useful output is obtainable with the transistor alone, making it ideal for use with printed circuit boards.

Abridged data

MAXIMUM RATINGS

Collector Voltage (Vcb)	DC or Peak, 15V (V15), 30V (V30)
Collector Current (Ic)	DC or Mean, 2A
Junction Temperature	75°C.
Collector Power Dissipation—	
(1) On 9 sq. in. of 16 swg aluminium, 2 Watts.	
(Derating 40 mW/°C. rise above 25°C.)	
(2) transistor only in free air, 0.5 Watt.	
Thermal Resistance (Junction to mounting surface)—10°C./W.	

CHARACTERISTICS

Collector cut-off current		50μA (max.)
Current gain (Beta)	−20mA	40 (typical)
	−150mA	25 ,,
	−500mA	16 ,,
Alpha cut-off frequency	−20mA	250 Kcs (Typical)

Typical applications

R.F. TRANSMITTERS
Output powers up to 3 Watts are possible at frequencies up to 500 Kc/s.

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Class A or B amplifiers operating at audio or radio frequencies.

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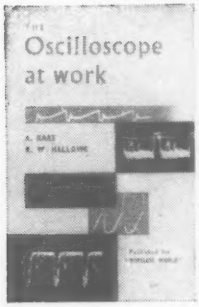

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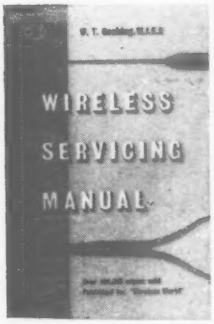

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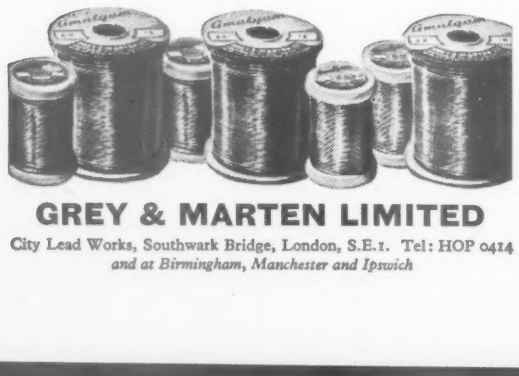

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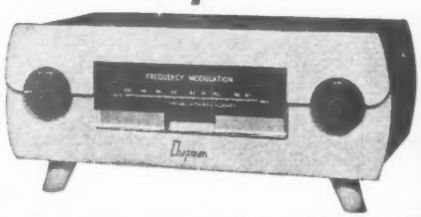

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Mozart Companion

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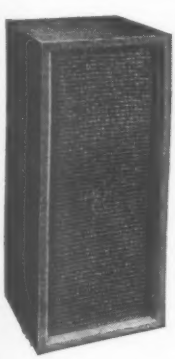
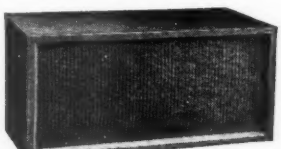
Introduced at this years' Audio Fair, the new Pye Mozart Companion 10-watt Speaker has been critically designed to match the outstanding performance and finish of the Pye Mozart Lowboy 10-watt Amplifier. It incorporates an 8" 15-ohm driver and a 4" 15-ohm tweeter mounted in a speaker enclosure of unique design. This is a totally enclosed folded isothermalized duct with the driver near one end, and an acoustic resistance coupling the closed end internally to control resonances. The crossover frequency is 7,000 c.p.s. The crossover network is inductive and capacitive.





A pair of Mozart Companion Speakers is more than adequate for stereophonic systems. The design ensures any two such units would be perfectly matched.
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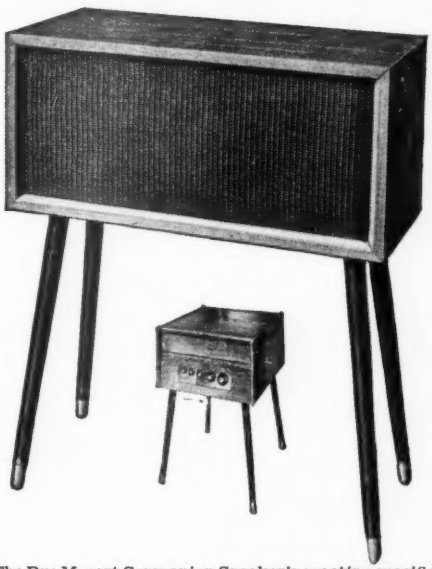

The Pye Mozart Companion Speaker's exacting specification has been reached only through good design and hand-finishing by experts. The hand of the craftsman may also be seen in its presentation. All surfaces are attractively veneered in walnut and fitted with interchangeable rubber feet for horizontal or vertical mounting. The clean lines and practical dimensions are in keeping with its character as a high quality electronic instrument.
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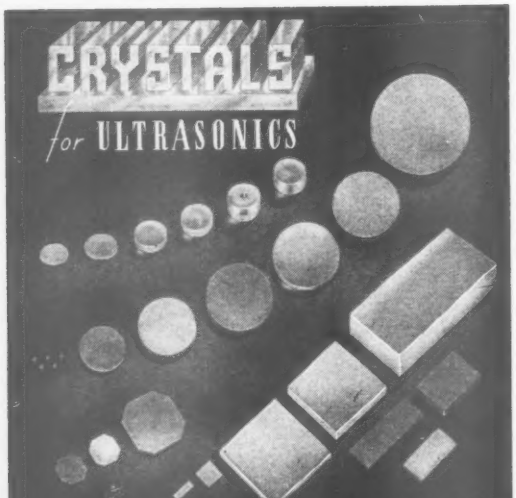

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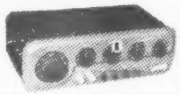
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The facilities incorporated in a tape recorder must be balanced with the quality of recording or reproduction its owner may wish to obtain. This is a design problem because the choice of Input Sensitivities and Input Impedances is important. So are Output Levels and their ability to match into external reproducers and amplifiers.

A Grundig tape recorder gives its owner three different types of Input Sensitivities and Input Impedances, suitable for a great variety of different Input sources. A Low Impedance Output is fitted for the connection of an external reproducer and a High Impedance Output is provided so that the signal can be fed to external amplifying and reproducing equipment.

The accompanying Chart gives the Input Sensitivities and Impedances as well as the Output Levels and Impedances for all Grundig Tape Recorders.

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RECORDER TYPES		500L	700L	700C	TK 9	TK 819	TM 819A	TK 12	TK 820	TK 5	TK 8	TK 830	TK 20
Micro	Sensitivity	2 mV	2 mV	2 mV	.07 mV	.07 mV	2 mV	2 mV	2.8 mV	2 mV	2 mV	1.5 mV	2 mV
	Impedance	200 Kohms	200 Kohms	200 Kohms	200 Ohms	200 Ohms	500 Kohms	500 Kohms	500 Kohms	500 Kohms	500 Kohms	470 Kohms	500 Kohms
Diode Input	Sensitivity	2 mV	2 mV	2 mV	2 mV	2 mV	2 mV	2 mV	2.8 mV	2 mV	2 mV	5 mV	7 mV
	Impedance	50 Kohms	50 Kohms	50 Kohms	500 Kohms	50 Kohms	50 Kohms	50 Kohms	50 Kohms	20 Kohms	20 Kohms	250 Kohms	250 Kohms
Radio	Sensitivity	400 mV	400 mV	400 mV	500 mV	500 mV	100 mV	100 mV	100 mV	100 mV	100 mV	100 mV	80 mV
	Impedance	1 Mohm	1 Mohm	1 Mohm	1 Mohm	1 Mohm	1 Mohm	2 Mohms	2 Mohms	1 Mohm	1 Mohm	1 Mohm	1 Mohm
High 'Z' Output	Level	800 mV	800 mV	800 mV	—	1.5 V	1 V	1.2 V	1.8 V	1.3 V	1 V	500 mV	1.8 V
	Impedance	10 Kohms	2 Kohms	2 Kohms	—	30 Kohms	50 Kohms	20 Kohms	20 Kohms	10 Kohms	10 Kohms	4.7 Kohms	10 Kohms
Low 'Z' Output	Power	2.5 W.	2.5 W	4.5 W	2.5 W	4.5 W	—	2.5 W	4.5 W	2.5 W	4.5 W	6 W	2.5 W
	Impedance	5 Ohms	5 Ohms	5 Ohms	5 Ohms	5 Ohms	—	5 Ohms	5 Ohms	5 Ohms	5 Ohms	15 Ohms	5 Ohms

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Forward Gain 8 dBs - - - - Impedance 70 ohms
Bandwidth - - - - - - 10 mc/s at 3 dB points
Front to Back Ratio - - - - - - - - - 25 dBs
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STANDARD SMOOTHING CHOKES

Catalogue Number	D.C. Current Milliamps	Inductance Henries	Approx. D.C. Resis. Ohms.	Model Size
P-2772	10	50	2000	9000/39
P-2773	25	10	520	9000/39
P-2774	25	25	1500	9000/39
P-2775	25	50	1200	9000/41
P-2776	50	10	700	9000/39
P-2777	50	20	850	9000/40
P-2778	50	50	1200	9000/49
P-2779	75	10	230	9000/41
P-2780	75	15	450	9000/41
P-2781	75	20	500	9000/49
P-2782	100	10	290	9000/41
P-2783	120	10	240	9000/49
P-2784	120	15	280	9000/49
P-2785	120	20	300	9000/57
P-2786	150	1·5	115	9000/41
P-2787	180	5	140	9000/49
P-2788	180	10	190	9000/57
P-2789	180	15	260	9000/57
P-2790	180	20	280	9000/65
P-2791	250	1·5	45	9000/41
P-2792	250	2·5	70	9000/49
P-2793	250	5	120	9000/49
P-2794	250	10	140	9000/65
P-2795	250	20	180	9000/73
P-2796	350	10	100	9000/73
P-2797	500	2·5	32	9000/65
P-2798	500	5	50	9000/73

The inductance quoted is measured at 10 volts, 50 c.p.s. with rated D.C. current

STANDARD MAINS TRANSFORMERS

Ref. No.	ELECTRICAL SPECIFICATION					Model Size
	Secondary 1	Sec. 2	Sec. 3	Sec. 4	Sec. 5	
P-2749	150–0–150 V. 25 mA	6·3 V. 0·6 A.	6·3 V. 0·6 A.	—	—	9000/41
P-2750	150–0–150 V 50 mA	6·3 V. 0·6 A.	6·3 V. 1 A.	—	—	9000/49
P-2751	150–0–150 V. 75 mA	6·3 V. 1 A.	6·3 V. 2 A.	6·3 V. 1 A.	—	9000/57
P-2752	200–0–200 V. 75 mA	6·3 V. 1 A.	6·3 V. 2 A.	6·3 V. 1 A.	—	9000/57
P-2753	250–0–250 V. 75 mA	0/5/6·3 V. 2·5 A.	6·3 V. 3 A.	6·3 V. 2 A.	—	9000/65
P-2754	250–0–250 V. 100 mA	0/5/6·3 V. 2·5 A.	6·3 V. 3 A.	6·3 V. 2 A.	—	9000/65
P-2755	250–200–0–200–250 50 mA	6·3 V. 1 A.	6·3 V. 1·5 A.	—	—	9000/49
P-2756	300–250–0–250–300 V. 180 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 3 A.	—	9000/73
P-2757	350–300–0–300–350 V. 75 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 3 A.	—	9000/73
P-2758	350–300–0–300–350 V. 100 mA	0/5/6·3 V. 2 A.	6·3 V. 3 A.	6·3 V. 1 A.	—	9000/65
P-2759	350–300–0–300–350 V. 120 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 4 A.	—	9000/73
P-2760	350–300–0–300–350 V. 180 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 4 A.	—	9000/73
P-2761	350–300–0–300–350 V. 250 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 4 A.	6·3 V. 4 A.	9000/81
P-2762	450–400–0–400–450 V. 120 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 5 A.	—	9000/73
P-2763	450–400–0–400–450 V. 180 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 4 A.	9000/81
P-2764	450–400–0–400–450 V. 250 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 4 A.	6·3 V. 4 A.	9000/81
P-2765	550–500–0–500–550 V. 120 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 5 A.	—	9000/81
P-2766	550–500–0–500–550 V. 200 mA	0/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 5 A.	—	9000/81

STANDARD FILAMENT TRANSFORMERS

Ref. No.	ELECTRICAL SPECIFICATION					Model Size
	Secondary 1	Sec. 2	Sec. 3	Sec. 4	Sec. 5	
P-2767	6·3 V. 1 A.	—	—	—	—	9000/39
P-2768	0–4–5–6·3 V. 2 A.	—	—	—	—	9000/40
P-2769	0–4–5–6·3 V. 3 A.	—	—	—	—	9000/41
P-2770	0–4–5–6·3 V. 2 A.	0/4/5/6·3 V. 2 A.	—	—	—	9000/41
P-2771	0–4–5–6·3 V. 3 A.	0/4/5/6·3 V. 3 A.	6·3 V. 3 A.	6·3 V. 3 A.	—	9000/65

- ✱ **DESIGN:** Complies with BSS2214
- ✱ **CONSTRUCTION:** Steel encased, compound filled
- ✱ **DIMENSIONS:** Plan and fixing to RCL215
- ✱ **HUMIDITY:** Category H2 or better
- ✱ **TERMINALS:** Patented design insulators, layout to RCL215
- ✱ **MOUNTING:** Upright or inverted all models
- ✱ **FINISH:** Grey hammer, stoved enamel

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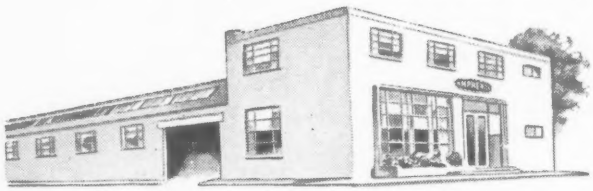

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HI-FI EQUIPMENT

(CABINETS See page 54)

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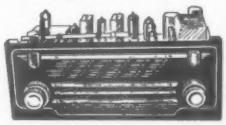

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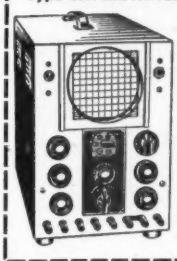

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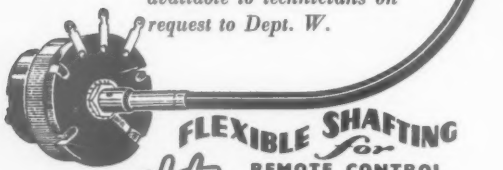

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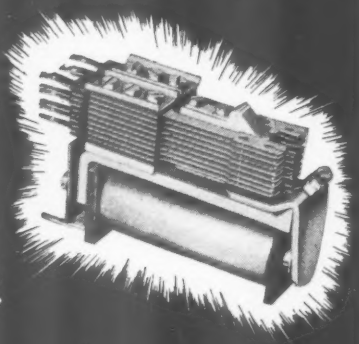

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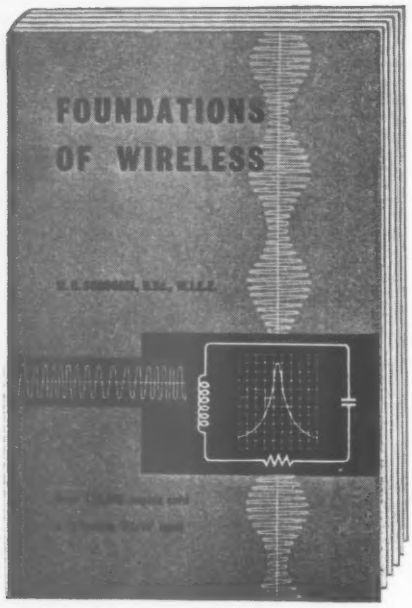

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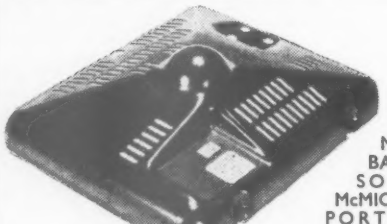

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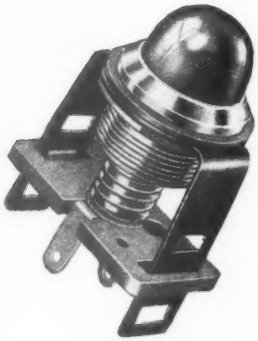

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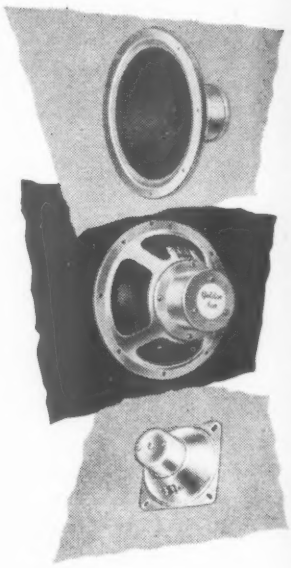

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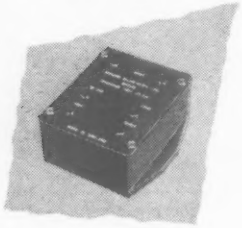

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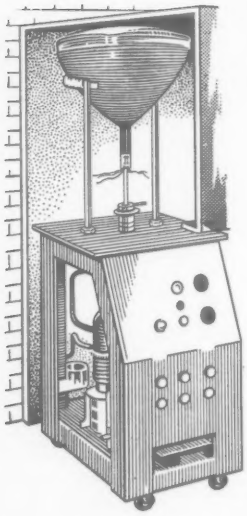

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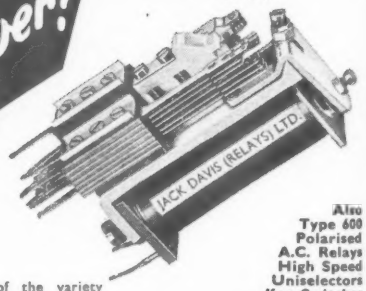

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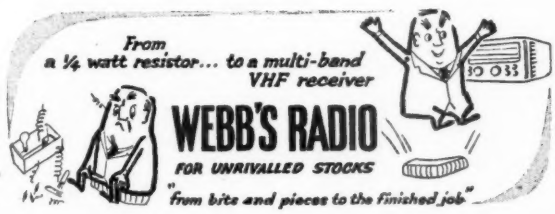
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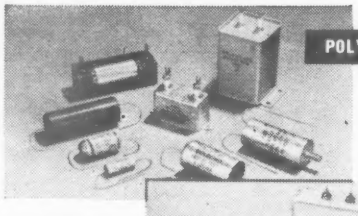

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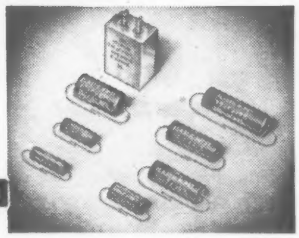

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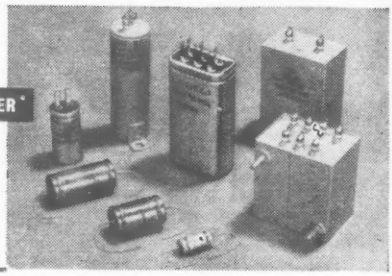

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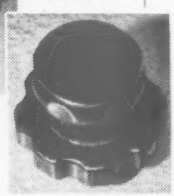

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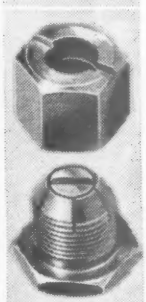

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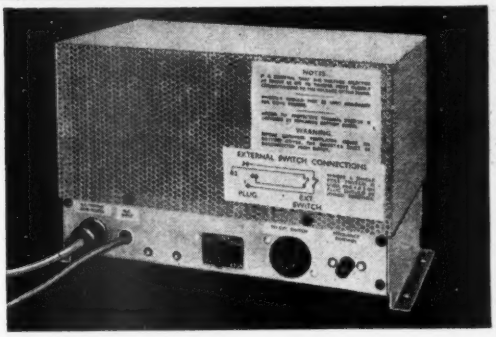

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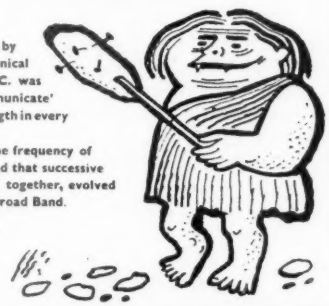

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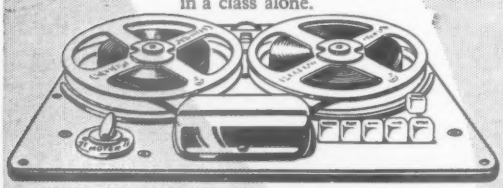

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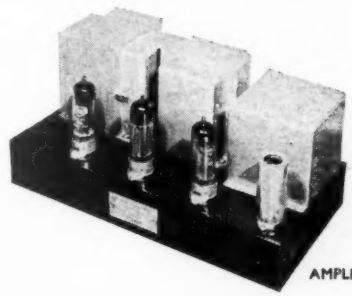

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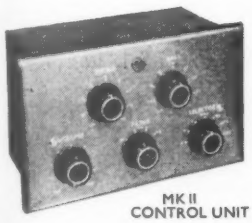

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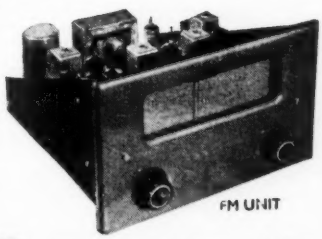

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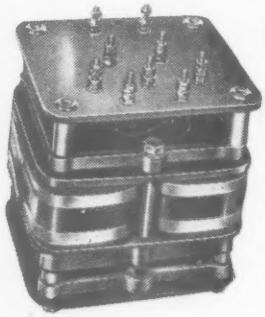

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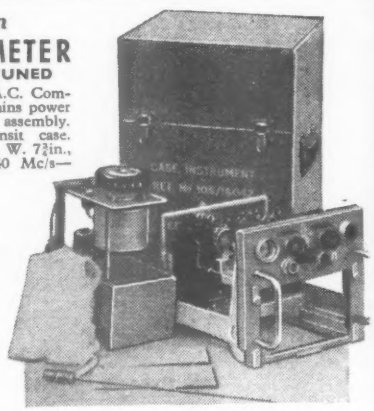

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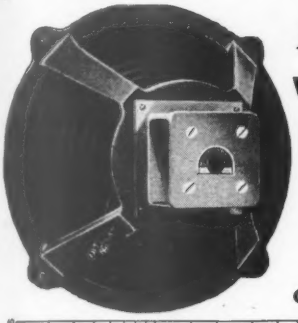

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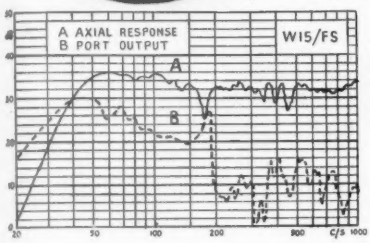

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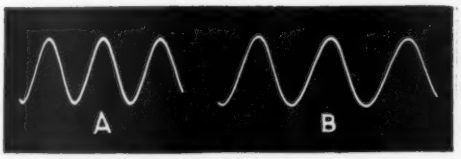

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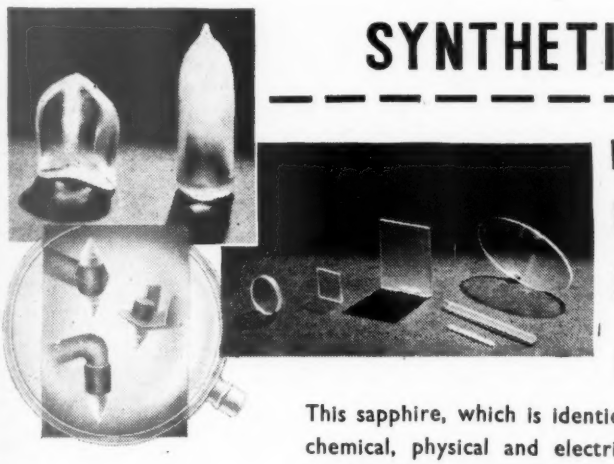

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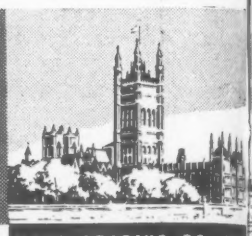

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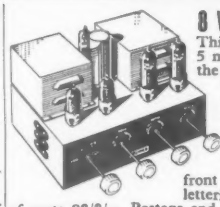

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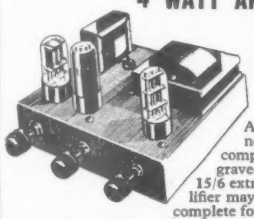

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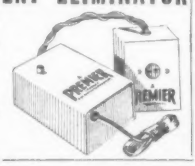

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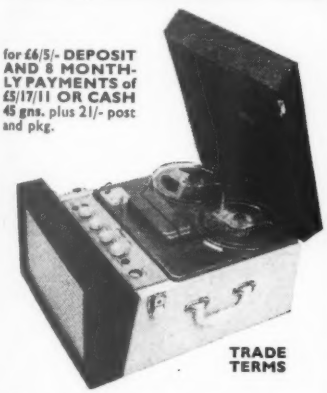

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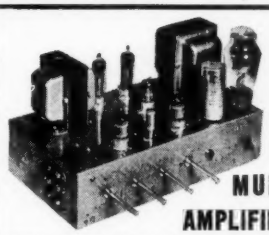

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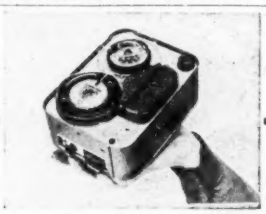

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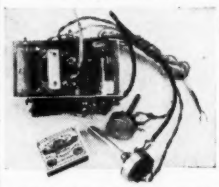

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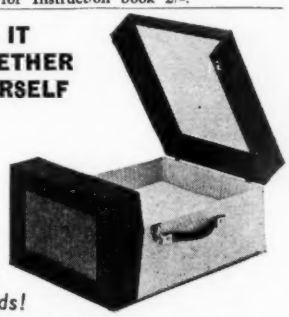

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Wireless World

ELECTRONICS, RADIO, TELEVISION

Managing Editor: HUGH S. POCOCK, M.I.E.E.
Editor: F. L. DEVEREUX, B.Sc.

JULY 1958

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Transistors Sliding-bias 4.5W Amplifier

The circuit shown is intended for car radio applications working from a 14V supply. The frequency response is quite suitable for this use, and distortion arising from the sliding-bias action is inaudible. The Mullard OC16 output transistor, in this circuit, produces nearly twice the output power normally obtainable in conventional Class A operation, with the same size heat sink. Because the d.c. currents vary with the signal, the circuit is exceptionally tolerant of continuous operation with speech and music, at high ambient temperatures up to 55°C. The only condition possibly dangerous to the OC16, is if the speaker is disconnected, whilst working at high ambient temperature.

Using sliding bias, the operating point of the transistor can be altered so that the d.c. input power varies with the signal. This enables the dissipation to be halved for the same output power, or the maximum output power to be doubled for the same dissipation.

The sliding bias varies the quiescent signal in conjunction with the amplitude of the output signal, so that it is always greater than the peak signal handled. Because, with speech and music, I_Q is rarely a maximum, the average current drain is appreciably less than the maximum value, and the average dissipation less than for an equivalent Class A stage.

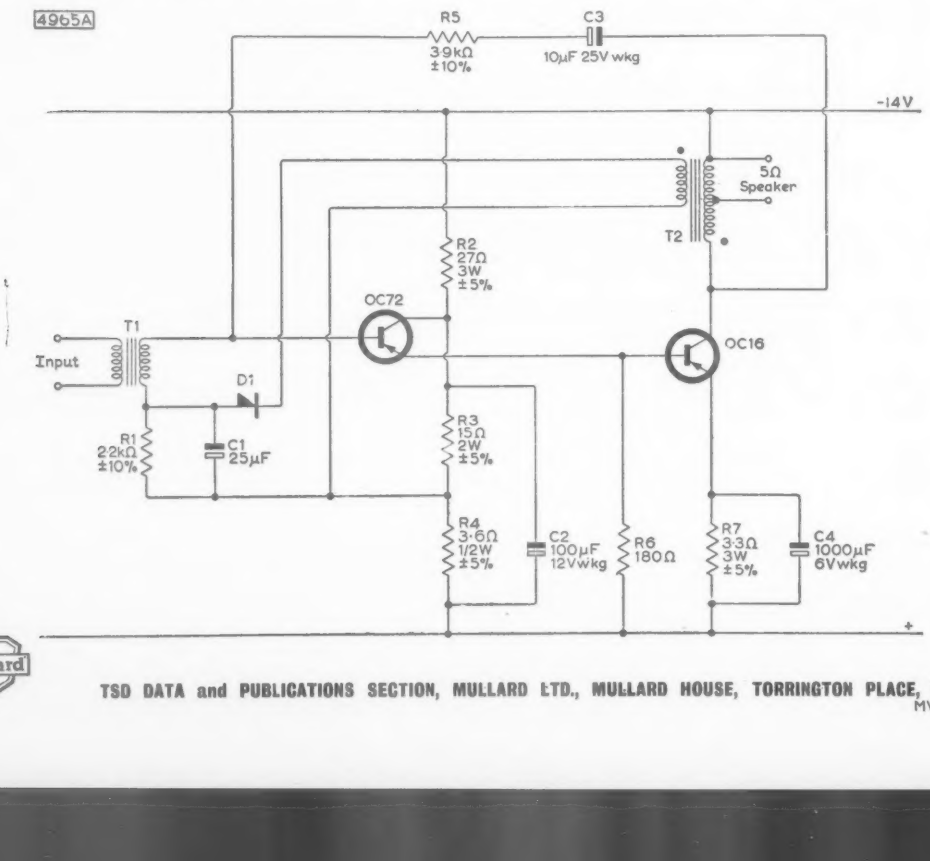
In a conventional Class A amplifier, designed for a junction temperature T_j of 90°C (T_{amb} = 55°C), this value of T_j is reached whenever T_{amb} equals 55°C. In this sliding-bias circuit (T_{amb} = 55°C) the maximum T_j is only reached under certain conditions, these are sustained sine wave input and a combination of limit characteristics of the transistors, which are not met in practice. Operation of the transistor at maximum T_j is unlikely, so that the life of the transistor should be longer.

The sliding bias is obtained from a secondary winding on the output transformer; it is rectified by a copper oxide rectifier (R_4 should be 3.9Ω), which is quite satisfactory, or a Mullard germanium diode (OA5 or OA10), which is slightly better in performance. The d.c. voltage, obtained across a capacitor (C1) and a shunt resistor, is applied to the base of the OC72 by way of the secondary of the driver transformer. Two problems not arising in conventional Class A amplifiers, must be solved, the elimination of transient distortion and the provision of correct sliding-bias action.

The first requires that the charging time constant of the bias circuit must be as small as possible; this is dependent on C1 and the forward resistance of the diode. For a lower frequency limit of 100 c/s, C1 must be 25μF. The discharge time constant must be chosen to avoid unnecessarily high dissipation of the OC16.

For correct sliding-bias action, the OC16 d.c. collector current must always be slightly greater than the peak a.c. collector current handled. The d.c. collector current depends on the bias at the base of the OC72. This is mostly derived from rectification of part of the a.c. collector voltage, which is directly proportional to the a.c. collector current.

The maximum collector dissipation likely is 7.2W for music drive with maximum transistor and resistor spreads.



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JULY 1958

Vol. 64 No. 7

Wireless World

Engineers in Association

MAN is a gregarious animal and the urge to communicate with his fellows is no less strong in engineers and technicians than it is in other members of the community. Whether it be the discovery of common interests with a complete stranger on a railway journey, participation in discussion at the local radio society or attendance at one of the Memorial Lectures of our great institutions one comes away with a sense of pleasure which is not altogether accounted for by any profit which may have been derived. Possibly the fact that engineering contains the elements of humanism and is less detached than the pure sciences may have something to do with this.

Community of interest and a willingness to impart as well as to absorb knowledge in discussion are the foundations upon which all successful associations have been built. The size of the membership will settle itself under the influence of the many factors which impel individuals to apply for and subsequently to continue membership. Inevitably there will be fluctuations which may show correlations with the external economic climate, the quality of the membership itself and the ratio of those who impart to those who merely absorb information.

The growth of knowledge and the changing pattern of industry will also result in a tendency to further specialization. This will give rise to regrouping either into cells within a larger association, or to the formation of new groups and associations. We see no cause for alarm in specialization provided that it is not pursued to the exclusion of the interchange of ideas between groups. The Royal Society of Arts sets a good example by welcoming as "institutions in union" comparatively new bodies, such as the British Sound Recording Association, which can both learn from and contribute to the traditions of skill and good taste established by the older society. Within the great engineering institutions the same object is achieved by frequent joint meetings of the specialist sections.

So far we have considered only the advantages of association for the advancement of knowledge and the individual benefit of members. Another important function is the establishment, as a condition of membership, of standards of professional competence and conduct which will be universally recognized as qualifications to practise—more particularly as independent consultants. This motive for association, which is similar to that of the ancient guilds, is one by which all the great engineering institutions are actuated. It is unthinkable that they should have separate codes of ethics, and the necessity for complete integration in this sphere seems axiomatic. On this point we are in agreement with Sir Arthur Whitaker, president of the Institution of Civil Engineers, who said at their recent annual dinner:

"Between the three major institutions we have, as always, the happiest of relations and we are going to try and see how much nearer we can get together. I am hopeful that somehow we shall find some way in which we can come extremely close together, because I believe that if we do that we shall make the engineering profession more cohesive. I believe it is a good thing. I do not like splinter groups. I do not like the suggestion that in order to cater for one particular branch of engineering you must set up a new institution. Engineering is a tremendous profession. It is a very varied profession. It covers so many things now that not even the greatest engineer can hope to be proficient in more than a moiety of it; but that is not to say that in organization we cannot get together and learn how to come under one rooof for engineering policy for the control of the profession."

We do not, however, share Sir Arthur's dislike of new splinter groups. These are apt to form and flourish with or without approval and will fully justify their separate existence if they extend the facilities for meeting and discussion and the spread of knowledge. The question of integration for other purposes can safely be left until they are as firmly established as the Institutions of Civil, Mechanical and Electrical Engineering.

Doppler Effect in Radio and Radar

I.—GENERAL PRINCIPLES

By N. M. RUST

SEVERAL articles have appeared recently in the technical press on applications of Doppler phenomena to radio and radar. Two of particular interest are "Airborne Doppler Navigation," by G. E. Beck, in *Wireless World* for May, 1957, and "Quantum's" "Fringe of the Field" article, "Son et Lumière," in the October, 1957, number of *Electronic & Radio Engineer*. The former describes a special application of Doppler to air navigation, while the latter gives a very clear exposition of the phenomenon from the point of view of relativity. The aim of this article is to draw attention to other uses of the phenomenon, and to various ways in which it comes into effect in radio and radar.

As "Quantum" has pointed out, it is rather unfortunate that the Doppler effect in sound is commonly used as basis of comparison for radio and radar effects. Apart from the question of velocity with respect to a medium, which has meaning with respect to sound vibrations in air but has no meaning in relation to radio phenomena, there are other factors which lead to a completely different outlook. In sound we are concerned with the change of pitch of a note when there is relative movement between transmitting and receiving points, and we measure pitch directly. In radio we do not directly measure the frequency of the received wave. The practical application of the phenomenon for velocity determination, and position finding, leads to the comparison by interference of the frequency of radio oscillations received from a relatively moving source with that of a reference oscillation from a fixed source at the receiving point. It is the pitch of the beat note that is measured, and not the actual Doppler frequency. This beat note we term the "Doppler note," and it must be distinguished from the "Doppler frequency" that is measured in the acoustical case.

In some applications it may be desirable, in order to obtain more precise information, to compare (by direct or indirect means) the "instant-by-instant"* phase of the two sets of oscillations. An understanding of the relative phase conditions affords the best means of establishing a picture of the phenomenon in its practical application to radio. If we understand what happens to the phase, instant-by-instant, what happens to the frequency difference, which is the thing we usually measure, will take care of itself.

Consider two oscillators that are very precisely synchronized. One is at a fixed point F, and the other at a moving point M. Initially M is placed at F, and the oscillators are brought into phase with one another. M is moved from F and its oscillations are radiated and received at F, and phase comparisons are made by means of a phase indicator. This is calibrated so that the angular position of the pointer corresponds to the phase difference between the received oscillations from M, and those of the oscillator at F.

Initially the pointer will read zero The velocity of radio waves is so very much higher than even that of a "sputnik" that it is not necessary to take account of the distance moved during the time of transmission of the signal from M to F. Any correction for such motion, although important in order to understand the phenomenon from the relativity point of view, would not effect any measurement that could be made under practical conditions. An (ideal) phase indicator pointer will therefore follow the movement of M. For every change of distance of one wavelength the pointer will make one turn and the direction of turning will depend upon the direction of motion.

If the phase indicator could be geared up to a counter so that the number of turns could be registered from the starting point, the counter would register the distance moved in wavelengths, and the fractions of a wavelength would be registered on the dial. If the rate that the needle was turning was counted in cycles per second, it would represent the radial velocity of M relative to F in wavelengths per second. The frequency of the oscillations from M received at F is the "Doppler frequency," and the difference between the frequencies of M and F, at F, is the "Doppler shift," or the "Doppler note"

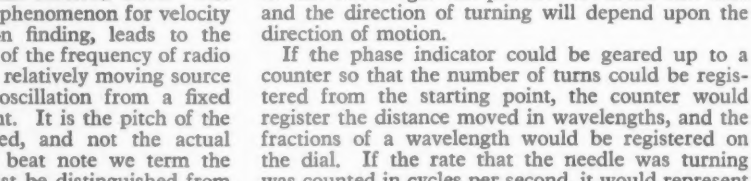


Fig. 1. Schematic of a Doppler radar station.

*The term "instant-by-instant" is preferred to "instantaneous," which conveys the impression of one event sharply defined in time. Doppler phenomena essentially concern moving objects. To understand and define them, we must think of a sequence of events sharply defined in time, and not merely of one event.

as it is usually called in radio or radar practice. Clear distinction should be made between the "Doppler frequency" and the "Doppler note."

Summarizing, then, the change in distance is represented by the total change in phase relationship, and the rate-of-change of distance (the radial velocity) by the frequency of the beat note. The scale units are defined by the wavelength of the transmitter.

Note that Doppler effect cognizes only changes in radial distance. Thus M may move in a circular path round F without causing any phase change or Doppler note. It is only the distances and velocities resolved along the radius connecting the two points, at any given instant, that are measured. If both relative bearings and relative distances are recorded instant-by-instant, the track of M relative to F is completely defined.

Perhaps the reader will say, "Although I quite understand your illustration, you have taken a hypothetical case that cannot possibly arise in practice, as you have assumed that the respective oscillators, at their positions, remain absolutely identical in frequency." The justification for this is that the more usual applications of Doppler effect are for radar purposes, in which the moving oscillator is replaced by a moving reflector illuminated from the fixed point. The difficulties of synchronization do not occur, therefore. Before considering the radar applications, however, there are several cases in which Doppler effect comes into play in ordinary radio practice, and these will be considered first.

One of the examples is in relation to single-sideband telephony from jet aircraft. If single-sideband telephony with suppressed or partially suppressed carrier is used, it is necessary to restore the carrier at the receiver by inserting a local oscillation. To obtain clear speech this must be at the right frequency. Let us consider the case of a jet aircraft flying at 600 miles per hour in the line of sight of a ground station, and transmitting on a frequency of 300Mc/s, or a wavelength of 1 metre. 600 m.p.h. is 880 ft/sec, or 278 wavelengths per second. If the aircraft is flying towards the ground station, the carrier frequency seen by this station will be raised 278 c/s above 300Mc/s. Similarly, if it is flying away on the line of sight the frequency received will be 300Mc/s − 278 c/s, and if flying transversely across the line of sight there will be no change of frequency and the carrier will remain at 300Mc/s. It will be seen, therefore, that Doppler effect presents quite a problem to the receiver designer in this case. His carrier restoring oscillator must follow these variations under all conditions to obtain clear speech.

Another important effect of Doppler in radio is in transatlantic reception of standard frequency signals, e.g., from station WWV (near Washington, U.S.A.). Ionospheric drift frequently produces quite appreciable Doppler effect, due to alterations in path lengths caused by the movement of reflecting ionospheric layers. Reference may be made to a paper "Doppler Effect in Propagation" by H. V. Griffiths of the B.B.C. in *Wireless Engineer* for June, 1947.

Perhaps, however, the most interesting application of Doppler effect in radio is that described in *Wireless World* for December, 1957, in connection with the radio observations on the Russian artificial satellites. The reader is referred to this article as it gives a very clear exposition of the way observations of Doppler changes in frequency were used, in conjunction with other data, to establish the track of the satellites.

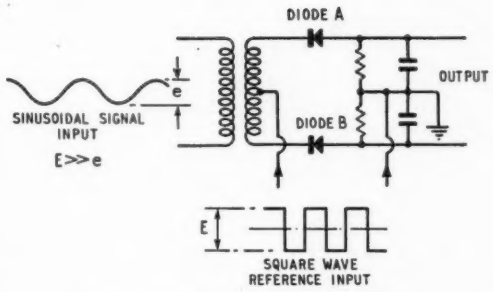


Fig. 2. Circuit of a phase-sensitive detector.

As these satellites are probably the most rapidly moving objects likely to be encountered for the present, it is interesting to check the difference in Doppler frequency derived from the Newtonian formula with that given by the Einstein type of formula derived by "Quantum." The last-mentioned provides a relativity correction factor of $(1-u^2/c^2)^{-\frac{1}{2}}$, where u is the velocity of the satellite, and c is that of light. The velocity of the satellite is given as 8 km/sec whilst c is 300,000 km/sec. The correction factor therefore works out as $(1-64/9\times10^{10})^{-\frac{1}{2}}$. This equals 1.000000000355. We are therefore, even in this extreme case, quite justified in using the ordinary formula, as the correction factor is far less than errors in measurement would be.

The illustration given above of the fixed and moving oscillators is easily adapted to radar principles. In this case we make the fixed oscillator at F radiate, and reflect the oscillations back to F by means of a moving reflector at M. This takes the place of the moving radiator. The echoes received are then compared in phase with the transmitted oscillations at F. The difference of phase is indicated by the pointer of a phase meter which makes one complete turn for every cycle change of phase The reflector M is first placed quite near to F, and adjustment is made to bring the phase meter reading to zero. We can assume that the time taken for the oscillation to complete the round trip from F to M and back is always insignificant in relation to the time taken to alter the total path length by one wavelength, or for an alteration of distance of one half wavelength. Therefore, for every change of distance of one half wavelength, the phase meter will complete one turn. The number of revolutions indicates the radial distance moved in half wavelengths, while the revolutions per second indicates the radial velocity in half wavelengths per second. Motion "to" turns the meter anti-clockwise, and motion "from" clockwise (using the same conventions as before).

M's track can be plotted by measuring instant-by-instant its Doppler phase and bearing, but there is no direct means of measuring range. Unless the radial velocity were very small, it would not be possible under practical conditions to follow the movements of a phase meter. It is therefore more practical to beat together the transmitted and received oscillations, and detect the beat note—the Doppler note. The frequency of this note gives the

radial velocity directly, which can be displayed on a frequency meter.

This method of displaying the Doppler information, which is usually the only practical one for fast-moving objects, introduces a difficulty. How can motion "to" be distinguished from motion "from," or vice versa? To the ear, or to the display, a note of 1,000 c/s may represent motion "to," or "from," of equal velocities; there is no means of distinguishing between them. If we had an electronic counter that would count either forwards or backwards, and register both positive and negative, the problem would be solved. Such a method is possible, but might prove complicated. The usual method of discriminating direction of motion will be described, therefore, especially as it affords an opportunity of bringing out some important features.

The problem is essentially that of distinguishing whether the beat note obtained by mixing a signal with a reference oscillator is due to a lower or a higher frequency than that of the reference oscillator. This has been successfully solved by a technique used for sideband cancellation in single-sideband telephony.

A Doppler radar station is shown schematically in Fig. 1. The receiver is shown at the top, and the transmitter just below it. The dotted line between them indicates that the receiving circuits are adequately isolated from the transmitter, so that they are not "swamped" by the transmitted signals. This may be accomplished, either by screening and separation, using separate transmitting and receiving aerials arranged so that the receiving aerial is placed on a null of the transmitting aerial, or by circular polarization methods. In the last-mentioned case it is possible to use a common aerial. Direct reception is indicated, but in practice special heterodyne methods would be used in order to obtain good signal-to-noise ratios.

The amplified signals are passed to two special detectors which, for want of a better name, have been called "phase sensitive detectors." Similar circuits have been called "synchronous" and "homodyne" detectors, but both these terms refer to the detection of signals of the same frequency and obviously do not apply when they are used as beat frequency detectors, as in the present case. Whilst not essential for the purpose, they are preferred because of special properties which are illustrated in Figs. 2 and 3. Fig. 2 shows one of the many forms of the phase sensitive detector that has been chosen for simplicity of illustration. Two diodes, A and B, are fed push-pull from the signal source, and push-push from a square-wave reference voltage derived from the transmitter. Fig. 3 shows that, choosing the received signal applied to A as the phase reference, when the signal and the square-wave reference voltage are in phase, charge is added to the high-frequency bypass capacitor connected to A and subtracted from that connected to B. An output voltage of one sign, say positive, is obtained. When the signal and reference waveform are in quadrature they do not change the charge on either capacitor, as they add and subtract for equal times. In anti-phase conditions, A now subtracts and B adds, resulting in a negative voltage equal to the positive "in-phase" voltage.

It is very simple to show that when the square-wave reference voltage E is big compared to the signal voltage *e*, the output bears a sinusoidal relation to relative phase in the way shown at the bottom of Fig. 3. It is clear, then, that if the phase detection process is carried out carefully the detected Doppler beats (the "Doppler note") will be sinusoidal.

Referring again to Fig. 1, as has been mentioned above, the square-wave reference source for the phase sensitive detectors is obtained from the transmitter. Phase sensitive detector 1 is fed in with in-phase reference oscillations (marked cosine), and phase sensitive detector 2 with quadrature phase retarded oscillations (marked sine). Beat note outputs are present at points D and E. That from phase sensitive detector 2 is quadrature phase retarded and acts

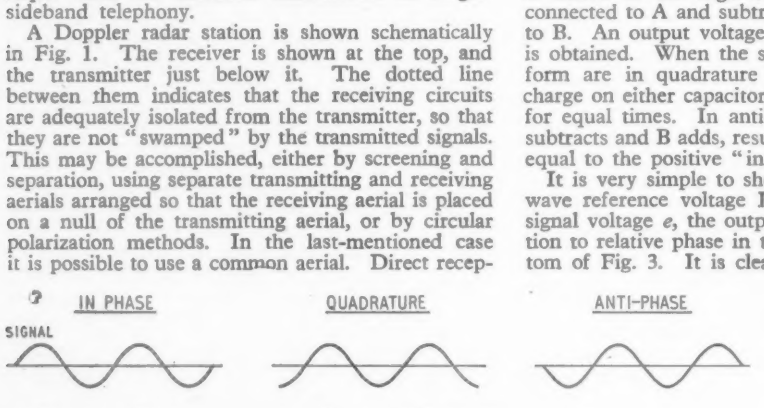


Fig. 3. Addition of the signal and reference waveform in Fig. 2 with different phase relationships. The lower shaded portions represent the non-conducting condition.

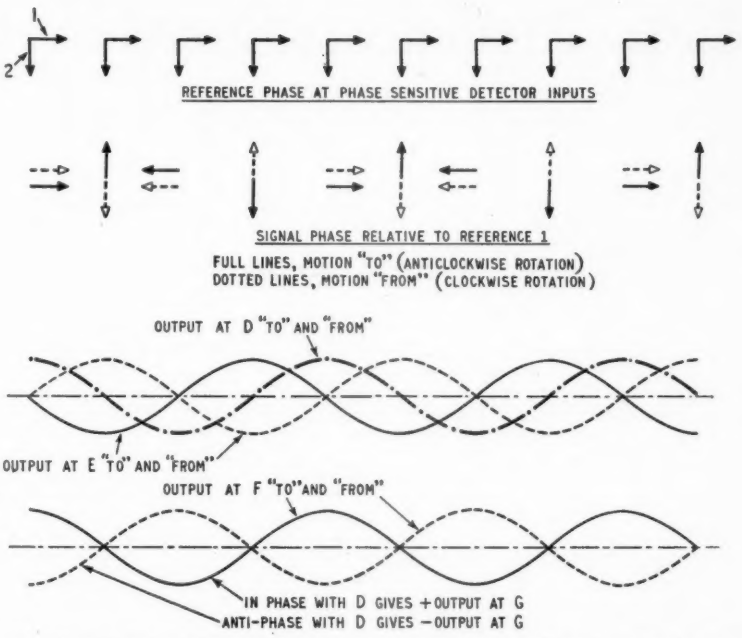

1
2
REFERENCE PHASE AT PHASE SENSITIVE DETECTOR INPUTS
SIGNAL PHASE RELATIVE TO REFERENCE 1
FULL LINES, MOTION "TO" (ANTICLOCKWISE ROTATION)
DOTTED LINES, MOTION "FROM" (CLOCKWISE ROTATION)
OUTPUT AT D "TO" AND "FROM"
OUTPUT AT E "TO" AND "FROM"
OUTPUT AT F "TO" AND "FROM"
IN PHASE WITH D GIVES +OUTPUT AT G
ANTI-PHASE WITH D GIVES −OUTPUT AT G

Fig. 4. Phase relationships of the signal and reference waveforms in Fig. 1.

as the reference oscillator to phase sensitive detector 3, the other input of which is fed from the cosine source, phase sensitive detector 1. Phase sensitive detector 3 has a d.c. output that changes in sign with the direction of motion of the reflector. By inserting limiting circuits and differentiating networks in the appropriate places, the amplitude of the output can be made proportional to the radial velocity. The radial velocity can, therefore, be displayed in convenient units as positive for one direction and negative for the other.

Fig. 4 shows how directional discrimination is carried out. Phases are indicated every 90°, starting from an instant at which the received signal at B in Fig. 1 is in phase with the cosine transmitter feed at A. All phases are referred to the last-mentioned. These relative phases define the envelope curve of the interfering high-frequency oscillations, and hence the beat note. Thus, when the signals are in phase with the reference oscillation, there is maximum beat note output from the phase sensitive detector, when in anti-phase this is reversed, and quadrature conditions give no beat frequency output. "To" signals are shown by full lines, producing anti-clockwise rotation of the relative phase vector, and "from" signals are shown by dotted lines with clockwise rotation. The amplitudes of the outputs of phase sensitive detectors 1 and 2 at D and E are obtained by comparing the relative phases of the signal inputs with the corresponding reference oscillations. It will be seen that they are in quadrature, and that the sine output reverses in phase with the direction of motion, whereas the cosine output does not. The result of subjecting the sine output to a 90° phase retardation is shown at the bottom of the diagram. It will be seen that it has pulled the beat note signals for "to" into phase with the output from D, whilst the "from" signals are thrown into anti-phase. The phase sensitive detector 3, in which comparison is made between the signals from D and F, cognizes this and a positive potential is registered at the output G for "to" signals, and a negative potential for "from" signals.

(To be concluded.)

BOOKS RECEIVED

Calculus for Electronics by A. E. Richmond. Working textbook, illustrated by upwards of 450 problems in electronics which can best be solved by the use of the calculus. Early chapters deal with basic functions and operations and lead to the use of Maclaurin, Taylor and Fourier series and the solution of differential equations. There is a useful appendix of tables of functions. Pp. 409; Figs. 146. Price 46s 6d. McGraw-Hill Publishing Co., Ltd., 59, Farringdon Street, London, E.C.4.

Pulse and Time-Base Generators by D. A. Levell, M.Sc., A.M.I.E.E. Concise survey, supported by an extensive bibliography, of linear and non-linear circuits, pulse modulators for radar, trigger circuits, electromagnetic time-bases and transistor circuits. Pp. 175; Figs. 166. Price 25s. Sir Isaac Pitman & Sons, Ltd., Parker Street, London, W.C.2.

An Approach to Audio Frequency Amplifier Design. Discussion of considerations leading to the design of seventeen amplifiers and pre-amplifiers for outputs from 5 to 1,100 watts which have been built and tested by the G.E.C. Valve and Electronics Department. Pp. 125; Figs. 75. Price 10s 6d. The General Electric Co., Ltd., Magnet House, Kingsway, London, W.C.2.

The B.B.C. Colour Television Tests: An Appraisal of Results by W. N. Sproson, M.A., S. N. Watson, A.M.I.E.E., and M. Campbell, B.Sc.(Econ.). B.B.C. Engineering Monograph No. 18. Description of transmitting and receiving equipment used in field trials, and a statistical analysis of observers' reports. Pp. 39; Figs. 4 and 24 tables. Price 5s. B.B.C. Publications, 35, Marylebone High Street, London, W.1.

Hi Fi Year Book, 1958. Directory of pickups, amplifiers, radio tuners, microphones, tape recorders and loudspeakers with introductory articles by well-known authorities. A separate section is devoted to recent developments in stereo sound. Pp. 208; Figs. 340. Price 10s 6d. Miles Henslow Publications, Ltd., 99, Mortimer Street, London, W.1.

Tape Position Indicator

By B. H. PARKS

Light Operated Relay System Giving Accurate Location

THE need for a satisfactory device for accurate tape marking in domestic recorders was shown by correspondence* from readers of *Wireless World* following an editorial in August, 1955, and an article by Price and Frewer the previous April. Tape thickening, low frequency recording, and metallic contact have been used, there being advantages and disadvantages with each method. Most tape deck manufacturers fit some form of counter or clock-face indicator, this being usually operated from the take-up mechanism. This method is only approximate as the requirements of positive drive, i.e., independence of tape stretch or slip on the spool, are rarely met. Also it depends on correct zero resetting at the beginning of each tape. For stage sound effects, it must be possible to find the required place on the tape quickly and accurately. The device described here was designed for such stage use, and is accurate to within a few milliseconds irrespective of changes in the tape length or spooling. It can, if required, be used while fast winding or rewinding.

For use at playing speeds up to $7\frac{1}{2}$ in/sec, a required position on the tape is marked by removing a strip of the oxide coating about $\frac{1}{32}$in wide across half the width of the tape; a wider gap being required for higher speeds. A low power lamp and a phototransistor are mounted on the deck on opposite sides of the tape. The gap in the oxide coating allows sufficient light to pass to the phototransistor so that it bottoms (conducts fully), allowing a current of 4 to 5mA to pass to operate a relay. This can then be used to operate a lamp indicator; or a stepping switch to count the gaps and then stop the tape where required or mute the amplifier.

* September and October 1955, pp. 427, 497.

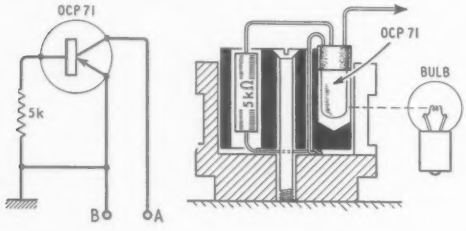
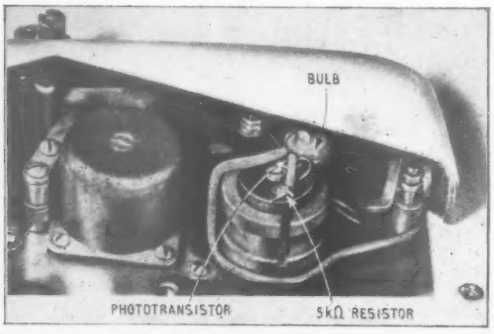


Fig. 1. (a) Circuit of head unit. (b) Arrangement of head unit. Below: Mounting of head unit on tape deck.



Head Unit.—This consists of a 6.3V, 2W torch bulb on one side of the tape; and on the other side an OCP71 phototransistor and, for convenience, its associated 5kΩ resistor connected as in Fig. 1 (a). The bulb is underrun at 4V to prevent too much stray light reaching the phototransistor. On the Wearite deck which was used, the pressure arm of the automatic stop must be removed. This may readily be replaced if required, but, in any case, the present device performs the same function of stopping the deck at the end of the tape. The phototransistor is mounted with its connecting wires uppermost together with the 5KΩ resistor in a block of insulating material in the circular autostop tape guide. The sensitive area of the phototransistor is carefully positioned opposite the slot in the tape guide and behind the upper half of the tape, as shown in Fig. 1 (b) and the photograph.

The illuminating lamp was mounted under the front cover, directly opposite the slot in the tape guide but at least $\frac{1}{4}$in away from it to allow the tape to be dropped into place without hindrance. The lamp was connected through a 6Ω resistor to the existing 6.3V supply on the deck.

Associated Circuits.—Fig. 2 gives the circuit of a simple unit with lamp indication only; while Figs. 3(a) and 3(b) show the circuit and layout of a selector unit with 11 positions, neon lamp indicators, and facilities for stopping the tape or muting the amplifier at any of the 11 positions. Either unit can be operated from a −50V supply.

Either a relay or a transistor may be used for muting; but if a transistor gate (for example, see *Wireless World*, March, 1958, p. 109) is used, it should be applied to one of the later amplifier stages, or additional noise may be introduced.

Indicator Unit.—This is shown in Fig. 2. It con-

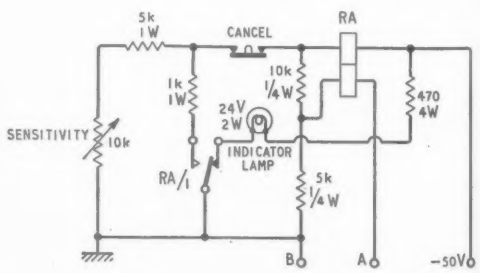


Fig. 2. Indicator unit.

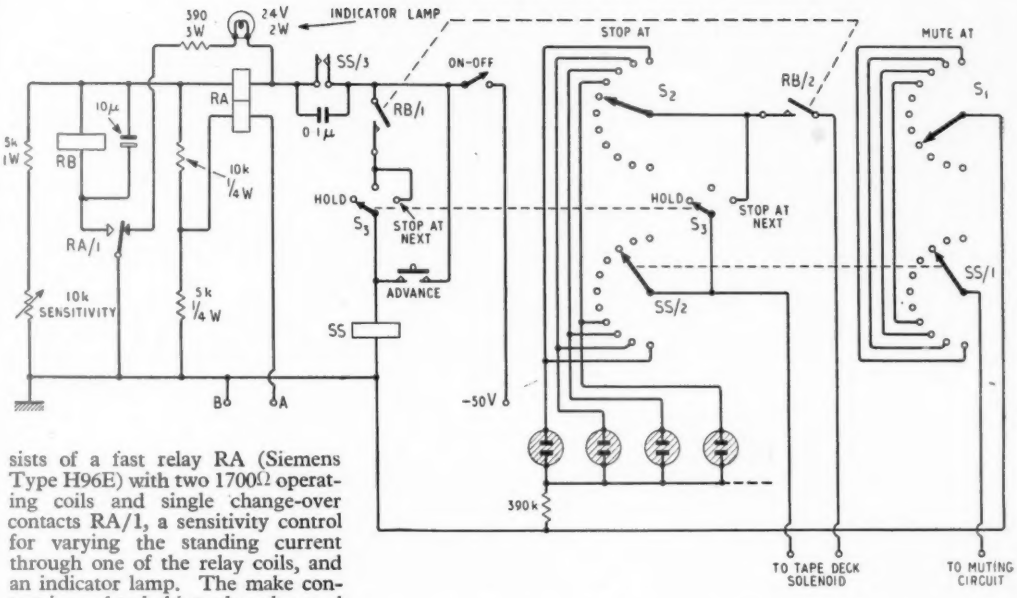
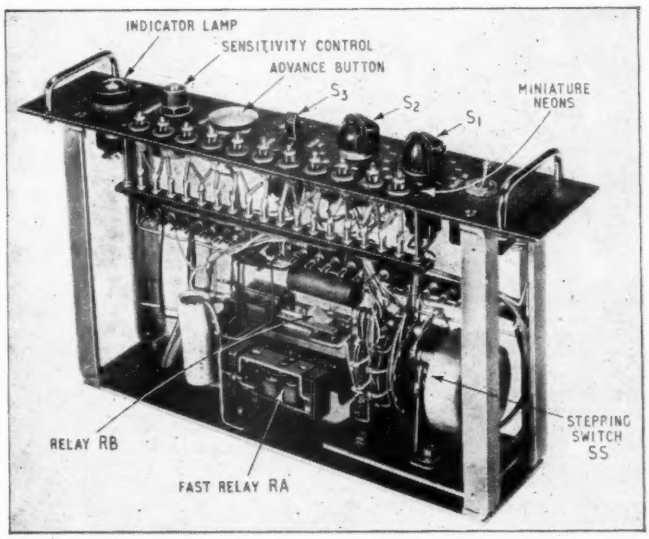


Fig. 3. (a) Circuit of selector unit. (b) Layout of selector unit.



sists of a fast relay RA (Siemens Type H96E) with two 1700Ω operating coils and single change-over contacts RA/1, a sensitivity control for varying the standing current through one of the relay coils, and an indicator lamp. The make contact is used to hold on the relay, and the break contact is used in the lamp circuit. Operation is signified by the lamp going out. It is necessary for the relay to hold on when it makes, otherwise it would operate so quickly as to escape observation. A push button to reset the relay is thus required.

An additional current of 4mA through both coils for approximately 20msec will operate the relay, the standing current of about 9mA through one coil being insufficient for this purpose. The circuit is arranged so that at no time can the potential across the transistor rise above 20V, nor can the current through it exceed 5mA. A point to note is that the sensitivity control cannot be directly in parallel with the transistor, as the current through this control would then fall almost to zero when the transistor bottomed, and nearly the full relay current would have to be carried by the transistor.

Selector Unit.—The circuit shown in Fig. 3 (a) is just one of many possible arrangements. It can be used for counting up to 11 positions at one time, and stopping the deck or muting the amplifier at any of these positions. For simplicity, connections for only 4 of the 11 positions are shown. The input circuit is the same as in the indicator unit, except that a second relay RB (Post Office Type 3000) is connected in the hold-on circuit of the first relay. This second relay has a 10μF capacitor across its single 2000Ω coil to hold it in sufficiently long to allow the deck solenoid to release when required. A slugged relay could equally well be used. This second relay has two pairs of heavy duty make contacts. One pair of contacts (RB/1) is used to operate a 50V N.S.F. stepping switch SS; the function of the second pair will be mentioned later. Each operation of this relay moves the stepping switch forward one position. This switch carries two wafers, each with 11 positions. One of these wafers (SS/1) is used with a manually set single pole 11-position switch S_1 to provide an earth contact for muting an amplifier. The other (SS/2) is used with another manually set 11-position switch S_2 for shorting the tape deck solenoid, and so stopping the tape transport mechanism. The h.t. voltage on

the solenoid is used to illuminate one of 11 miniature neon lamps, so indicating the position of the stepping switch. To prevent the manual 11-way switch S_2 from illuminating the neon lamp corresponding to the position to which it is set, the second pair of contacts (RB/2) on the second relay keep this circuit open, except during operation. With this arrangement, the neon lamp on the position to which the manual stop switch is set lights momentarily at each operation. Resetting of the two relays is carried out by a pair of contacts SS/3 on the stepping switch which open each time it operates. An "advance" push button can be used to manually shift the stepping switch to any required position (without shorting the tape deck solenoid). A 2-pole 3-way switch (S_3) is provided to stop the deck at the next mark or to prevent the stepping switch from operating, the third position allowing normal operation as described previously.

On reaching the end of the tape, the phototransistor is continually illuminated, and the stepping switch moves round at intervals of about $\frac{3}{4}$ sec per step until it reaches the position at which the stop switch is set. The tape transport then stops, and a microswitch on the deck can be used to cut off the 50V power supply from the unit.

Sensitivity.—A gap of $\frac{1}{2}$in corresponds to just over 4msec at $7\frac{1}{2}$ in/sec, or over 8msec at $3\frac{3}{4}$ in/sec. This will cause the relay to operate at either speed. The gap is in "view" of the phototransistor for about $\frac{1}{8}$in of travel; or 17msec at $7\frac{1}{2}$ in/sec. The narrowness of the gap is not limited by the sensitivity of the instrument, but the difficulty of making a narrower gap.

For locating individual items in a tape at a full wind-on speed of about 800 feet per minute a gap approximately $\frac{1}{4}$in long is required. It may be possible to reduce this length by using narrow staggered or sloping gaps, but this has not been tried.

Removing the Oxide Coating.—This can usually be done using acetone on a small paint brush. However, with some tapes the backing is affected by acetone, so it is always best to initially test a sample of each make and type of tape. Where acetone softens the tape backing, it has always proved possible to remove the oxide with cellulose enamel thinner. Paper-backed tapes have not been tried.

It is advisable, where possible, to make gaps before recording, since they are then extremely difficult to detect. If gaps are made in a recorded tape without subsequent erasure, some oxide is always disturbed and causes a faint "tick."

Re-use of Tape.—When the tape comes to be re-used, the gaps cause no noticeable effect in the normal way. However for re-use with this device, the gaps must first be blacked out, and black enamel can be used for this purpose. The $\frac{1}{4}$in wide gaps should only be used with recordings of a permanent nature.

Microwave Valves

POINTERS FROM THE I.E.E. CONVENTION

THE great variety of methods now used to generate microwaves, and the big differences between these methods and those used in valves for lower frequencies were well exemplified in more than one hundred papers given at the Convention organized recently by the Institution of Electrical Engineers.

Parametric Amplifiers—This type of amplifier, which has recently been applied to microwaves, is based simply on varying the inductance or capacity in a tuned circuit, i.e., on varying a circuit parameter.

The tuned circuit is made resonant at the signal frequency, f_s say, and the capacity, say, is varied at another frequency known as the pump frequency, f_p say. For suitable phase differences between f_p and f_s, power at f_p is converted into power at f_s, and may be used to produce amplification or oscillation.

Parametric amplifiers have some similarities to modulators with gain such as magnetic or dielectric amplifiers. However, with these latter, the amplified power is obtained in the sidebands at $f_p \pm f_s$ rather than directly at f_s.

In one simple type of parametric amplifier, the tuned circuit capacity is increased when there is a signal voltage across it, and decreased when, twice every signal cycle, there is not. In the former case the energy stored in the capacity is increased; in the latter it remains unchanged. Thus the energy needed to vary the capacity is transferred to the signal circuit.

Since in this simple type of amplifier the capacity is decreased twice every signal cycle, the pump frequency f_p is twice the signal frequency f_s. If f_p is made slightly different from $2f_s$, it may be regarded as a frequency of $2f_s$ whose phase varies at $2\pi(f_p - 2f_s)$. This phase will then be correct for amplification for part of the time, and f_p need not be synchronized to f_s. (It is difficult to synchronize two different microwave frequencies.) This type of parametric amplifier gives the maximum gain for a given bandwidth (or *vice versa*).

Practical Microwave Parametric Amplifiers.—In the first of these, the precession (motion like a wobbling top) of the magnetic moment of spinning electrons in a ferrite about the direction of an external field was used to give variably inductive coupling between the pump circuit at 9 kMc/s and the signal circuit at 4.5 kMc/s.[1]

Such spin states have also been used in masers.[2] Unlike masers (microwave amplification by stimulated emission of radiation), parametric amplifiers are not restricted to use with atomic or molecular quantum energy levels. Other advantages of parametric amplifiers over masers are a much greater maximum output power, and the very small amounts of extra noise introduced by the amplifier even at normal temperatures. Low temperature operation is generally necessary with masers to secure long enough relaxation times.

The use of reversed bias p-n junction diodes as variable capacities in parametric amplifiers was discussed in a

paper by Chang and Bloom, who used a pump frequency less than the signal frequency; and also by Uhlir, who reported operation up to 9000 Mc/s with noise figures from 1.0 to 1.5dB at room temperatures.

Capacitive or inductive coupling using modulated electron beams in cavities was discussed in a paper by Ashkin, Bridges, Louisell and Quate.[3] In such beams there are two space charge density waves at the signal frequency—one wave having a lesser and the other a greater velocity than the electrons themselves. The faster wave corresponds to electron energies greater than the d.c. energy of the beam, and the slower wave to electron energies less than the d.c. energy of the beam. Thus, where the only power source is the d.c. energy, as in conventional microwave valves, only the slower wave can be amplified. With the additional pump power source of parametric amplifiers, the faster wave can be amplified. In this case, the noise contributed by the beam is very much less, and a possible disadvantage of electron beam parametric amplifiers is avoided. In an experimental valve, the beam first passed through a cavity tuned to the f_p of 8300 Mc/s and into which pump power was fed, next through a cavity tuned to the f_s of 4,150 Mc/s and into which the input signal was fed, and then through a second suitably spaced cavity tuned to f_s from which the amplified signal output was obtained. The distance between the two cavities was different from that in a normal two-cavity klystron. In such a klystron this distance would correspond to a transit phase difference between the cavities of $(2n + 3/2)\pi$. Actually it corresponds to $(2n + 2)\pi$ or $(2n + 1)\pi$ for capacitive or inductive coupling respectively (n is any whole number). With inductive coupling, if the drift space is also short compared to the plasma wavelength, the noise currents in the two gaps are equal and opposite. These currents can then be cancelled out.

Several authors discussed the possibilities of increasing the at present narrow bandwidth of parametric amplifiers and masers by using long broadband structures embedded in material with a high density of effective electron spins and along which an electromagnetic travelling wave can be propagated. As is unfortunately often the case, increased bandwidth can only be obtained at the expense of decreased gain. Calculations suggest that, for useful gains in a reasonable length, the bandwidth can only be increased up to a few per cent of the centre frequency.

Doppler Effect Frequency Multiplier—In the type discussed by R-Shersby-Harvie[4], the input signal at the fundamental frequency f is propagated in the opposite direction to a beam of electrons bunched at a frequency f_o. A signal at a frequency of $nf_o + f$ (where n is a whole number) and travelling in the same direction as the beam can then be induced if the velocity of the electrons is suitable. This velocity must be chosen so that, due to the Doppler effect, to the electron the fundamental and induced signals have the same frequency. These signals can then interact through the electrons.

In microwave valves, interaction is usually with electromagnetic waves travelling much slower than the velocity of light. Such waves, which are known as slow waves, can only be propagated in special slow-wave structures such as the helix. If the operating frequency is increased, such structures must be decreased in size. They are then more difficult to make, and also cannot dissipate so much power.

In this use of the Doppler effect, for frequency multiplication by up to about ten both signals can travel fast enough to propagate in ordinary smooth-walled waveguides, and no slow-wave structures are necessary. The electrons' kinetic energy can also be less than the rest energy.

M-J Valve—This modification of the M-type valve was described by Johnson and Birdsall. The best known example of an ordinary M-valve is the magnetron. In M-valves the electrons move mainly at right angles to and under the influence of both electrostatic and magnetic fields which are at right angles to each other. The electrons also drift in the direction of the electrostatic field from the negative cathode to the positive anode or collector, i.e. at right angles to their main motion. The anode is usually also made the slow-wave structure, and the electron motion is confined to one plane by end plates.

In the M-J valve the electrodes are rotated through 90° about the main direction of electron motion, the electrostatic and magnetic fields being left unchanged. The electrons then go to an electrode separate from the slow-wave structure. Power dissipation problems in small slow-wave structures at high frequencies are thus avoided. The use of j to denote 90° rotation explains the choice of name (for which the authors apologized!).

The electron motion in M-J valves is in three directions at right angles instead of two as in M-valves. M-J valves should give a higher gain than M-valves without any reduction in efficiency.

E-type valves[5]—A Russian paper by Tchernov reported recent developments. In such valves, the electrons describe circular or spiral orbits, the centrifugal force being balanced by a radial electrostatic field. The first variety was called a magnet-less magnetron.

In the Russian anti-klystron, the electrons move inside a hollow ring describing spiral orbits about a circular electrode placed centrally inside the ring. The electrons can interact with an electromagnetic wave travelling at right angles to the plane of the ring and passing through its centre. The operating frequency is fixed only by the rotational velocity of the electrons, and the electromagnetic wave can be synchronized with a harmonic of this velocity. Slow-wave structures may thus not be necessary, and operation at very short wavelengths should be easy.

Travelling-wave Klystron Amplifier—A new variety was described by Heathcote, Lindsay, Barraclough and Newby[6]. Here the electrons can interact with fast waves in smooth-walled waveguides because they travel at right angles to these waves. The input and output signals travel one in each of two parallel waveguides. Ideally, the electrons should form a sheet beam passing first through the input and next through the output waveguide through slits along the guide lengths[7]. In practice, however, it has proved difficult to produce satisfactorily focused sheet beams in these conditions.

In the authors' modification, the sheet beam is replaced by a number of separate cylindrical beams passing through the guides in the same direction as the sheet. The waveguides are also periodically loaded with inductive irises placed across their widths midway between each beam and its two neighbours. While this loading increases the power output and efficiency, it reduces the bandwidth to about 10%. This valve is similar to a number of two-cavity klystrons connected in parallel side by side, the cavities being joined to form the two waveguides.

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1 H. Suhl, *Phys. Rev.*, April 1957, p. 384, and M. T. Weiss, *Phys. Rev.*, July 1957, p. 317.

2 See for example *Wireless World*, May 1957, p. 212, or J. P. Wittke, *Proc. I.R.E.*, March 1957, p. 291.

3 See also T. J. Bridges, *Proc. I.R.E.*, Feb. 1958, p. 494, and W. H. Louisell and C. F. Quate, *Proc. I.R.E.*, April 1958, p. 707.

4 I.E.E. Paper No. R2646.

5 See for example A. Versnel and J. L. H. Jonker, *Philips Research Reports*, Vol. 9, Dec. 1954, p. 458, and H. Heffner and D. A. Watkins, *Proc. I.R.E.*, Vol. 43, Aug. 1955, p. 1008.

6 I.E.E. Paper No. R2628.

7 T. G. Mihran, *Proc. I.R.E.*, Vol. 40, March 1952, p. 308.

The "Cathoguard"

By L. G. WHITE

Wideband Amplifier of Improved Rise Time

DESIGNING wide-band pulse amplifiers is a problem which revolves round the types of valves currently available. The only circuit improvements which have increased the ratio of bandwidth to gain are the use of suitable filter sections to reduce the effects of stray capacitances and the application of small amounts of voltage negative feedback.

The design of filter sections for pulse amplifiers is limited by the overshoot which occurs if the full bandwidth for the steady sine wave condition is used. Most pulse amplifiers use simple series peaking as being the best compromise. The more involved filters are more difficult to adjust and are very dependent on valve capacitances for their performance. By using voltage negative feedback some improvement can be made but the delay time of the amplifier itself prevents more than a small gain in performance. It is useless to apply large amounts of negative feedback because it does not act until the signal has reached the output of the amplifier, by which time it is too late to apply feedback to the leading edge of the pulse! This results in overshoot of the leading edge of the pulse and little improvement in the rise time. To reduce this undesirable effect to a minimum an individual feedback loop is connected round each amplifier stage. Speaking generally, negative feedback gives little improvement in the pulse rise time.

TABLE I

Inter-electrode Capacitances for EF91
EF91 with normal holder (valve cold)
g_1 to all others 9.5 pF
a to all others 3.5 pF
Using a three terminal bridge (Wayne Kerr B 221)
a to all others g_3 neutralized 1.3 pF
g_1 to all others g_2 neutralized 7pF
g_1 to g_3, all others neutralized 1 pF

TABLE II

Inter-electrode Capacitances for EF80
EF80 with normal holder (valve cold)
g_1 to all others 9 pF
a to all others 5.5 pF
a to all others g_3 neutralized 4 pF
g_1 to all others g_2 neutralized 3 pF
g_3 and a to g_1 all others neutralized 0.15 pF

With the above points in mind, work was started to find some other means of improving amplifier pulse rise time. As the valve capacitances seemed to be the limiting factor, measurements were made on an EF91 valve to find how the capacitances were made up. Table I gives the results.

This shows that 2.2 pF of the output capacitance is due to the suppressor grid and 2.5 pF of the input capacitance to the screen grid. The output capacitance would be very much reduced if the suppressor grid were driven from a generator giving it the same potential as the anode. There would be no voltage difference between the electrodes, therefore no energy would be stored in the capacitance. This is, in effect, similar to the use of "guard-ring" measuring techniques. A suitable circuit to put into practice this capacitance removing effect is shown in Fig. 1.

The normal amplifying stage (V1) feeds a cathode follower (V2). The output could be taken in the normal way from the anode of V1, but as the cathode follower gives a lower output impedance it is better to take it from the cathode of V2.

The suppressor grid base of V1 is about 35V for a 10% drop in mutual conductance so the feedback voltage will have little effect on the normal operation of V1. However, it will "remove" nearly all the anode to suppressor grid capacitances.

Further Improvements

As it stands, the circuit has several disadvantages—the most important is the Miller capacitance due to the 1 pF control grid to suppressor grid and anode capacitance of V1 and the grid to anode capacitance of V2. The control grid to anode capacitance can be effectively removed in V2 by the circuit of Fig. 2. The screen-grid of V2 is now at nearly the same a.c. potential as V2 control grid—so removing, in effect, the input capacitance The Miller capacitance due to the 1 pF control grid to suppressor grid and anode of V1 can be overcome by using a valve in which

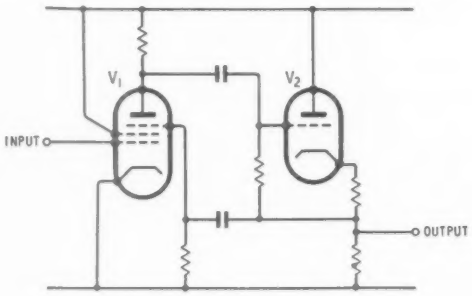


Fig. 1. Reducing effective output capacitance.

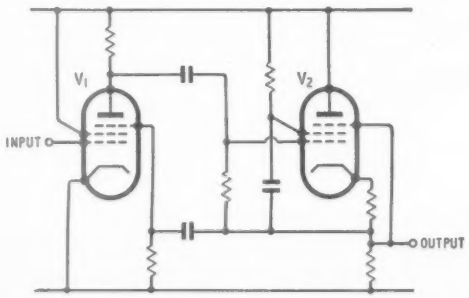


Fig. 2. Reducing input capacitance of cathode follower.

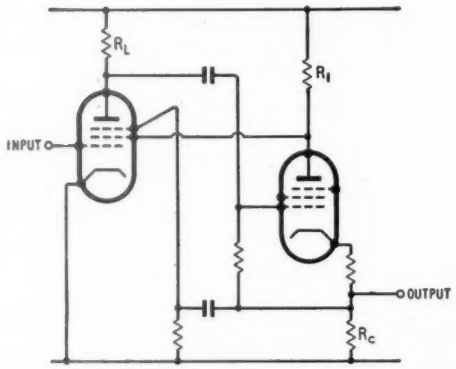


Fig. 3. Another modification reduces V1 input capacitance and produces the "Cathoguard".

the internal screen is not connected to the suppressor grid. The EF80 was found to be a more suitable valve and Table II gives the capacitances measured.

The anode and suppressor grid to control grid capacitance is now only 0.15 pF and the Miller effect is no longer important. The rest of the output capacitance is to the internal screen—no doubt other valves are available which would give better screening of the anode by the suppressor grid.

The circuit of Fig. 2 can still further be improved by feeding the screen grid of V1 with a voltage of the same phase and amplitude as that on the control grid. This will effectively remove the control grid to screen grid capacitance. Fig. 3 shows a simple way of doing this.

The value of R_1, the cathode follower anode load, to give the correct voltage is approximately:—

$$\frac{10R_c}{9g_m R_L}$$

where R_a is in kΩ, R_c and R_1 in identical units. In a typical case where $g_m = 10$mA/V, $R_a = 10$KΩ, $R_c = 1000\Omega$, $R_1 \simeq 11\Omega$.

From the economic point of view it looks at first sight as if no improvement is obtained in the "Cathoguard" which could not be obtained from two conventional stages of amplification in cascade. To compare the two systems the example of a typical two-valve amplifier is taken and gain/bandwidth product is determined (Fig. 4).

Considering one stage in Fig. 4, for a response −1.5dB at 10Mc/s, $fCR^* = 100$

$$C = 15\text{pF}, f = 10\text{Mc/s}$$
$$\therefore R_1 = 0.66\text{k}\Omega$$

The nearest standard value is 680Ω.

$\therefore R_1 = R_2 = 680\Omega$ for a response 3dB down at 10Mc/s.

Voltage gain (A) $= g_m R_L$,
$g_m \simeq 10$mA/V, $R_L = 680\Omega$
$\therefore A = 6.8$ per stage
i.e. stage gain $\simeq$ 17dB

Thus over the complete amplifier gain is 34dB; 3dB down at 10Mc/s, falling at 12dB/octave. For a standing anode current of 8mA the output amplitude is limited to roughly seven or eight volts, peak-to-peak.

*W. T. Cocking, "Television Receiving Equipment", (Iliffe) 4th Edition, page 213, Fig. 15. 3.

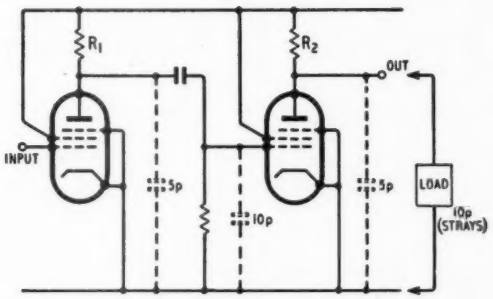


Fig. 4. Skeleton circuit of a conventional pulse amplifier.

Comparing the "Cathoguard" of Fig. 3 with 5 pF stray capacity across R_a for 3dB down at 01Mc/s, R_a can be increased to 3kΩ and the gain becomes 30dB for a g_m of 10. This compares very favourably with Fig. 4 gain of 34dB. But the "Cathoguard" only falls off at 6dB/octave, until the cathode follower fails, which need not occur until the frequency is raised to about 30Mc/s.

The main advantages of the "Cathoguard" are:—

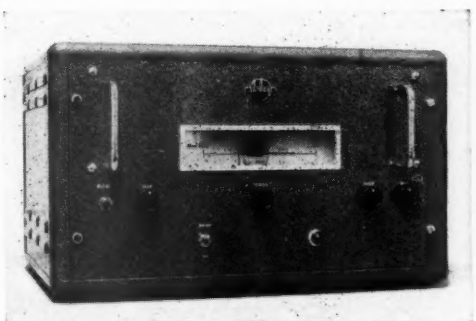
(1) The input capacitance is reduced.

(2) The output impedance is lower (on pulse rise time only).

(3) Due to the response dropping at only 6dB per octave, pulse rise time is improved without increasing the frequency of the 3dB-down point.

(4) Voltage negative feedback could be used to improve gain stability, due to the good phase response. Negative feedback is not of much use on the circuit shown in Fig. 4.

Even with valves available at present the "Cathoguard" would seem to be an improvement on the normal pulse amplifier, and with special valves and valveholders very much improved pulse amplifiers could be built. The ideal valve would have a screen round both the control grid and anode. Both screens would be brought out to separate pins and the valveholder would continue this screening.



Combined v.h.f./f.m. tuner, gramophone and microphone pre-amplifier and 25-watt amplifier designed for factory entertainment and announcements. Units with other power outputs from 6 to 100 watts are available, and the amplifiers (with pre-amplifiers) may also be obtained separately. The makers are Hadley Telephone and Sound Systems, Ltd., 72, Cape Hill, Smethwick, Staffs.

WORLD OF WIRELESS

Electronic Forum for Industry

IN an endeavour to provide a clearing-house for the exchange of information as a step towards co-ordinating technical committee work, research, development and application of data processing techniques in industry, nine industrial organizations have formed what is to be known as the Electronic Forum for Industry (E.F.F.I.).

It is also hoped it will provide a channel for the presentation of the British industry's point of view in international discussions concerned with electronic automation and computation.

Organizations taking part, so far, in addition to the Electronic Engineering Association (formerly R.C.E.E.A.), who were the conveners, are:—

British Radio and Electronic Manufacturers' Association.
British Radio Valve Manufacturers' Association.
Machine Tool Traders' Association.
Office Appliance and Business Equipment Trades Association.
Radio and Electronic Component Manufacturers' Federation.
Society of British Aircraft Constructors.
Scientific Instrument Manufacturers' Association.
Telecommunication Engineering and Manufacturing Association.

C. Metcalfe, chairman of the Data Processing Section of E.E.A., who presided at the first meeting said, "The E.F.F.I. will not assume the work or responsibilities of the individual associations, nor will there be any impingement on the work of the professional institutions. The Forum will be a co-ordinating body to help to guide industry through the growing complexity of electronics."

The E.E.A. is acting as secretariat for the Forum.

Tax on Reconditioned C.R. Tubes

TO help to clarify the intentions of H.M. Customs and Excise to levy purchase tax on certain types of reconditioned television tubes the following has been issued:—

"Under the law Purchase Tax becomes due on all goods of a class chargeable with tax when they are sold or appropriated by a registered or registrable person under taxable conditions. The fact that the goods may be reconditioned goods does not affect the position. As a concession, however, the Commissioners do not require tax to be paid on secondhand goods even if they are sold or appropriated under taxable conditions provided that the goods have been subjected to no more than minor repairs and are kept segregated from new goods both physically and in the trader's accounts.

"The general position in respect of reconditioned cathode-ray tubes is as follows:—

(1) Where only a *minor* reconditioning process has been carried out (i.e., where the tube has only been treated externally) the concession referred to above is applicable.

(2) A registered or registrable person carrying out *extensive* reconditioning work (i.e., work involving the opening of the tube) incurs liability to payment of tax where—

(a) the work is such as to amount to the manufacture of a virtually fresh tube (e.g., where the original electron gun is replaced by a fresh, not necessarily new, gun); or

(b) the tube is sold or appropriated under taxable conditions.

"If the processor does not ensure that a tube sent to him by a customer for extensive reconditioning is returned to that same customer, the transaction is a sale and tax liability is incurred under (b) above, whether or not liability is incurred under (a).

(3) A registered or registrable person having his own tubes extensively reconditioned by another person incurs liability to payment of tax when the tubes are sold or appropriated under taxable conditions.

"A person becomes registrable when his gross takings from sales of chargeable goods which he has manufactured (including virtually fresh cathode-ray tubes) and/or sales by wholesale of extensively reconditioned tubes and other chargeable goods exceed or are likely to exceed £500 a year, on average. Any person who becomes liable to registration is under legal obligation to apply for registration through his local Officer of Customs and Excise within 14 days."

From section 2(a) it seems clear that if the original gun is reconditioned and replaced in the same tube there will be no liability to purchase tax provided that the transaction does not in other respects amount to "sale or appropriation under taxable conditions."

Birthday Honours

SOME well-known names in the world of wireless appear in the Queen's Birthday Honours List.

Dr. Willis Jackson, Metropolitan-Vickers' director of research and education since 1953, who for some years before that occupied the chair of electrical engineering at Imperial College, London, is appointed a Knight Bachelor.

Among those appointed Commanders of the Order of the British Empire are P. A. T. Bevan, chief engineer of I.T.A., who was for 20 years with the B.B.C. and was on the editorial advisory board of our sister journal *Electronic & Radio Engineer;* and E. K. Cole, chairman and managing director of Ekco.

Appointments of O.B.E.s include W. T. Ash, secretary of the Radio and Electronic Component Manufacturers' Federation; Wing Cdr. R. C. Lawes, senior overseas liaison officer, International Aeradio; and D. S. Watson, senior principal scientific officer, Admiralty Signal and Radar Establishment.

H. V. Griffiths, engineer-in-charge of the B.B.C.'s Tatsfield Receiving Station, is appointed M.B.E.

Computer Exhibition

ALL available space at the Electronic Computer Exhibition to be held in the National Hall, Olympia, London, from November 28th to December 4th, has been taken by the forty-five firms exhibiting. During the exhibition, of which H.R.H. The Duke of Edinburgh is patron, a symposium on computer applications and operation will be held.

The exhibition and business computer symposium are being organised, at the instigation of the National Research Development Corporation, by the Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association. The exhibition organizer is Mrs. S. S. Elliot (O.A.B.E.T.A., 11-13, Dowgate Hill, London, E.C.4). Immediately preceding the exhibition there is to be an associated scientific symposium organized by the National Physical Laboratory at Teddington, Middlesex, from November 24th to 27th.

Radio in the U.S.

FACTS and figures from the annual report of the Federal Communications Commission of America, quoted by *Electronic News,* show that about 1.25M fixed and mobile transmitters are in use in the U.S.A. For every broadcasting transmitter in operation there are about 50 other transmitters in use.

About a quarter of the fixed and mobile stations are for land transport, including 105,500 for taxis and 51,300 for railways. Another 25% are for indus-

trial mobile radio and some 20% for public safety services—police, fire, etc.

There are approximately 3,300 a.m. broadcasting stations, some 800 television stations and over 700 f.m. transmitters. For the first time for nine years the number of f.m. stations has increased.

Over 90% of the population is within the service area of at least one TV transmitter and about 80% of all American homes now have a television set. Of the 44.5M sets in use, the Report states that 160,000 are colour receivers. Some 250 stations are equipped to transmit colour.

U.H.F. Mobile Radio.—What is understood to be the first British equipment for u.h.f. mobile radio to receive the P.M.G.'s approval has been designed by Elliot Brothers (London), Ltd., for operation in the 460-470 Mc/s band.

East-Anglian TV station at Tacolneston, near Norwich, which has been working on reduced power since its opening in 1956 to avoid interference with the Belgian station at Liège, is now operating on full power. The Liège transmitter, which shares the same channel, is now using a higher power transmitter. Tacolneston's directional aerial gives an e.r.p. of 1.3 to 15kW depending upon direction.

Manchester Electronics Show.—The 13th annual exhibition and convention organized by the Institution of Electronics will be held at the Manchester College of Science and Technology from July 10th-16th (excluding Sunday). Some 75 manufacturers, including some from abroad, will be exhibiting and there will also be displays by a number of scientific and industrial research organizations. Complimentary admission tickets for the exhibition and convention are obtainable from W. Birtwistle, 78, Shaw Road, Rochdale, Lancs., from whom the catalogue (price 2s 9d) is also obtainable.

Radio-Controlled Models.—The annual contest for radio-controlled model boats organized by the International Radio Controlled Models Society will be held on August 3rd and 4th, on the Model Yacht Pond, East Park, Kingston upon Hull. Particulars of the contest, which is open to non-members, are obtainable from A. S. Wilson, 14, Biddick Lane, Fatfield, Washington, Co. Durham.

GERMAN POLICE RADAR
Extensive tests of Telefunken radar speed measuring equipment are being carried out by the Hamburg and Frankfurt traffic control police with a view to its use not only for speed limit enforcement but also for statistical purposes. The linear speed scale is calibrated in km/hour and an overall accuracy of ± 3% is claimed. There is provision for recording, in conjunction with an automatic camera, the speed and identity of any vehicle which exceeds a given limit.

Two new laboratories were officially opened at the Royal Radar Establishment, Malvern, by the Minister of Supply on May 27th. One of the labs is devoted to research work on the physics of solids and the other houses the greater part of the guided weapons department of the establishment.

I.E.E. annual report for 1957/58 records that of its 43,231 members, 5,765 are members of the Radio and Telecommunication Section. This section held more meetings (24) during the year ended in March than any of the other three specialized sections, and the average attendance at its London meetings was 237.

British Computer Society.—The first annual report of the society records a membership of 1,300 at the end of April. During the year eight regional branches have been formed. The society recently moved to Finsbury Court, Finsbury Pavement, London, E.C.2. (Tel.: Monarch 6252.)

I.F.A.C.—The constitution of the International Federation of Automatic Control, founded in Paris last September, has now been ratified by organizations in 12 countries. The Federation plans to hold its first congress for automatic control in Moscow from June 25th-July 5th, 1960. The address of the I.F.A.C. secretariat is c/o Verein Deutscher Ingenieure, 79 Prinz-Georg-Strasse, Dusseldorf, Germany.

Control Engineering.—A readership in control engineering has been established at the Battersea College of Technology, London. The first lecturer to be appointed is N. Ream who, prior to joining the engineering staff of the college, was in the control section of the National Physical Laboratory. At McGill University, Montreal, a chair of control engineering has been instituted.

University Scholarships.—The first 20 university scholarships have been awarded for 1958 under the scheme established by the English Electric Co. earlier this year to provide professional training for young men likely to attain senior engineering positions. Each scholarship is worth £450 a year for three years.

War Office Civilian Studentships.—A studentship scheme sponsored by the Ministry of Supply on behalf of all the government departments employing scientists gives to a limited number of young men who intend to enter the Scientific Civil Service a university education in science or engineering at the Royal Military College of Science, Shrivenham. Six civilian studentships tenable for three years have recently been awarded. Students are prepared for the London University B.Sc. degree.

High-Quality Reproduction.—A series of lectures on high-quality sound reproduction is being given by P. Collings-Wells, technical manager of Goodmans, at their Wembley works. Particulars of forthcoming lectures are obtainable from Goodmans Industries, Ltd., Axiom Works, Wembley, Middlesex.

Broadcast receiving licences current in the U.K. at the end of April totalled 14,621,275. Combined television and sound licences increased by 57,330, bringing the total to 8,147,333. Sound-only licences numbered 6,473,942, including 336,519 for car radio.

Amateurs' Emergency Work.—The clause in the Amateur (Sound) Licence prohibiting British amateurs sending messages for a third party was amended in 1956 to permit the passing of messages for the British Red Cross Society and the St. John's Ambulance Brigade "during disaster relief operations." At the request of the Home Office, the P.M.G. has now amended the wording to cover the passing of messages for the Police.

Personalities

S. E. Goodall, M.Sc.(Eng.), chief engineer of W. T. Henley's Telegraph Works Company, is the new president of the I.E.E. He has been a vice-president since 1953. Mr. Goodall represents the Institution on a number of national committees including the Board of Studies (Engineering) of the National Council for Technological Awards.

Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.Sc., director of electrical engineering in the Admiralty since 1945, is elected a vice-president of the I.E.E. for a second period of three years. Sir Hamish was for two years with the B.T.H. Company before joining the staff of the Admiralty in 1926 as assistant electrical engineer at the Chatham and Devonport Dockyards. He was at one time superintending electrical engineer of the Singapore naval base.

A. H. Mumford, O.B.E., B.Sc.(Eng.), deputy engineer-in-chief of the Post Office, has been elected a vice-president of the I.E.E., He was chairman of the I.E.E. radio section in 1945/46. Mr. Mumford joined the Post Office engineering department in 1924 and after a short period at headquarters went to the Dollis Hill research station. He took charge of the radio branch in 1938.

L. W. Brown, B.Sc., Ph.D., M.I.E.E., F.Inst.P., has been appointed assistant chief electrical engineer (light current) of Metropolitan-Vickers, in addition to his present duties as chief engineer of the company's electronics department. Educated at King's College, London, where he obtained his B.Sc. and Ph.D. working under Sir Edward Appleton on ionospheric research, he entered the Royal Air Force in 1939, and was engaged on the operational development of airborne interception by radar. In 1940 he joined T.R.E., and at Rugby collaborated in the development of centimetric radar. Three years later Dr. Brown went to the B.T.H. Company, where he continued the development of airborne, ground and marine radar equipment. He joined Metropolitan-Vickers in 1950 as chief engineer of the radio department, and since 1955 has been chief engineer of the electronics department. This department covers work on particle accelerators, digital and analogue computers, electronic railway signalling equipment and equipments for missiles.

Dr. L. W. BROWN

Sebastian Z. de Ferranti has succeeded his father, Sir Vincent de Ferranti, as managing director of Ferranti, Ltd. Sir Vincent remains chairman of the company.

A. E. Falkus, B.Sc.(Eng.), M.I.E.E., has left the Plessey Company, where for the past eight years he has been chief loudspeaker designer, and, together with **D. A. Newbold,** has formed Fane Acoustics, Ltd. (See "News from the Industry"). Mr. Falkus was at one time chief engineer of Reproducers & Amplifiers, Ltd., of Wolverhampton. Mr. Newbold was until recently technical director of Richard Allan Radio, Ltd., of which he was one of the founders.

J. Bell, B.Sc., F.Inst.P., has been appointed manager of the G.E.C. research laboratories at Wembley. He has been manager of the telecommunications division of the laboratories since its formation in 1953, and will retain the leadership of this work in addition to assuming the administration of the group of establishments. The responsibility for the laboratories' scientific policy and programmes will remain with the present director of research, **O. W. Humphreys,** C.B.E., B.Sc., F.Inst.P., who is also director of the company's applied electronics laboratories at Stanmore. Mr. Bell joined the G.E.C. in 1929, and his work has been largely in the field of radio and radar transmitting valves.

J. BELL

GRP. CAPT. L. R. RIDLEY

Grp. Capt. L. R. Ridley, O.B.E., assistant director, electronics research and development at the Ministry of Supply for the past four years, has retired from the R.A.F. and has joined Masteradio and its subsidiary R.M. Electrics. He has assumed responsibility for the company's radar and electronics division. Grp. Capt. Ridley worked under Sir Robert Watson-Watt in the pre-war development of radar and was responsible for maintaining the radar network in the S.E. sector during the Battle of Britain. Masteradio, which is a member of the Francis Sumner group of companies, was concerned with the war-time development of the original Eureka Mk. 1 and Rebecca Mk. 1 radar beacons.

Capt. G. J. A. Lumsden, D.S.C., R.N. (Retd.), has joined Decca Radar to lead a new sales division for naval shipborne radar, coast defence radar and harbour surveillance equipment. Capt. Lumsden was a specialist in navigation in the Royal Navy and has been closely associated with air defence, surface warning and navigational radar systems for many years.

Bernard Greenhead, appointed technical controller of A.B.C. Television, the television programme contractors for the Midlands and the North, started his television career as development engineer with E.M.I. where he worked on the development of the B.B.C.'s original television system. For two years he was with the B.B.C. prior to joining High Definition Films in 1953 as technical controller of the Highbury studios. Two years ago he joined Alpha Television Services—TV programme producers—as chief engineer, and subsequently became general manager.

J. W. Dick, who has been appointed representative in Singapore by the Marconi Marine Company, was for some time instructor at the Glasgow Wireless College before joining the company's sea-going staff. In 1950 he transferred to the shore staff and has been at the Liverpool depot.

Hilary F. C. Williams, whose appointment with Andec, Ltd., we mentioned last month, was assistant chief engineer of Racal Engineering, and not, as was inadvertently stated, chief engineer.

M. Minton is resigning on June 30th his position as chief development engineer of Cosmocord, which he has held for three years, to become chief engineer with the Dulci Company. Prior to joining Cosmocord he was for 16 years with the Air Ministry and Ministry of Supply engaged on the development of navigational aids.

M. MINTON

J. H. R. Manners, B.Sc., deputy head of the Brimar valve application department of Standard Telephones and Cables at Footscray for the past five years, has joined Masteradio as chief development engineer. For seven years before joining S.T.C. he was with Felgate Radio.

R. G. Friend, B.Sc., M.A., F.Inst.P., has been appointed director of electronics research and development (telecommunications) in the Ministry of Supply in succession to **Brigadier J. D. Haigh,** O.B.E., who has retired. When Brigadier Haigh was appointed in 1954 there were only two directorates of electronics research and development—air and defence—now there are three, ground, air and telecommunications. Mr. Friend has been assistant director since 1954. Before the war he was at the Air Defence Experimental Establishment, Biggin Hill.

F. C. Brooker, A.M.I.E.E., has been appointed by the B.B.C., engineer-in-charge, London (sound), in succession to **C. E. Bottle,** M.B.E., who has retired after 34 years' service with the corporation. Mr. Brooker joined the B.B.C. in 1935, and in 1941 became an instructor in the engineering training department, where he remained until 1948. During this period, he wrote the B.B.C.'s first engineering training manual.

Gordon F. Wylde has joined Benjamin Electric, Ltd., as assistant manager of the radio department. He was for five years at T.R.E. (now R.R.E.) and three years at the Royal Aircraft Establishment, Farnborough. He then joined E.M.I. Engineering Development as components liaison engineer, and for the past three years has been with McMurdo Instrument Company.

N. MacKinlay, B.Sc., who joined Richard Allan Radio, of Batley, Yorks., last year, has been appointed chief engineer. After graduating in natural philosophy and mathematics at the University of Glasgow in 1945, he joined the Royal Naval Scientific Service and was engaged in research in underwater acoustics.

OUR AUTHORS

N. M. Rust, the first part of whose article on the Doppler effect appears in this issue, was for many years in Marconi's research department until his retirement in 1955. During the war he was working for the Admiralty on micro-wave radar and was associated with the development of metal lens and f.m. and Doppler radar. Joining Marconi's in 1913 he was posted to Clifden transatlantic station as receiving engineer, and seconded to the R.N.V.R. for interception work during World War I. Mr. Rust was concerned with a number of propagation investigations and worked with Capt. H. J. Round on the development of oscillating crystal detectors, microphones for broadcasting and also steel tape magnetic recording equipment for the B.B.C.

L. G. White, who contributes an article on the "Cathoguard" in this issue, joined Wayne Kerr Laboratories as an apprentice in 1948. After completing his apprenticeship he spent some time on the design of transformer ratio arm bridges and latterly was working on the application of measuring bridges in industrial control. He recently left Wayne Kerr and is now an electronic design engineer with Marconi Instruments at St. Albans.

OBITUARY

Sir Louis Sterling, D.Litt., who died on June 2nd at the age of 79, had served on the boards of a number of companies in the radio and gramophone industries. Rising from humble beginnings in the gramophone trade he became managing director of the Columbia Graphophone Company and subsequently of E.M.I. He resigned from E.M.I. in 1939 and joined the board of Cossor, becoming chairman in 1941. He left the company in 1943. At the time of his death he was a director of RCA (Great Britain). Sir Louis, who was knighted in 1937, served on the council of Brit.I.R.E. for some years and was president in 1943/44.

G. C. Cunningham, O.B.E., joint managing director and a founder director of Racal Engineering, Ltd., of Bracknell, Berks., died on May 16th. During the war he was in the Royal Air Force, serving mainly in Canada where, as deputy chief signals officer with the rank of Wing Commander, he was associated with the formation of the North Atlantic Ferry Command. In 1945 he was appointed signals controller of B.O.A.C. having been on the staff of Imperial Airways before the war. For a short while in the late 1940s Mr. Cunningham was with Plessey's as communications sales manager.

News from the Industry

Air Surveillance Radar.—Decca have produced a 3-cm long-range air-surveillance radar which, by utilizing two scanners back-to-back and at slightly different angles, gives an unbroken coverage up to a height of 40,000 ft. and to a distance of about 120 miles. Each scanner is fed from an 800-kW transmitter and both linear and circular polarization are provided. The first order for the equipment (D.A.S.R.1) has been placed by the Swedish Board of Civil Aviation for sets to be installed next year at the air terminal at Stockholm and the airport at Gothenburg.

Welwyn Electrical Laboratories, Ltd., held an open day at their works in Bedlington, Northumberland, at the end of May to celebrate the 21st anniversary of their establishment in Welwyn Garden City, Herts. The company manufactures something like 5,000 different types of resistor with about 30 per cent of the output going into sound and television equipment and the remainder to industrial, engineering and military equipment.

Silicon Production.—A new technique for the production of hyper-pure silicon, originally developed by Standard Telecommunication Laboratories and employed commercially by Standard Telephones & Cables at their Harlow works, is to be used under licence in America and Canada by the Du Pont Company. The process, which involves the thermal conversion of silane gas into silicon, enables silicon of the highest purity to be produced.

Relay Exchanges, Ltd., and its subsidiaries, which include the receiver renting companies Rentaset, had a trading profit of £1.6M in 1957 compared with £1.4M in 1956 and £0.97M in 1955.

Aero Research, Ltd., of Duxford, Cambridge, which is affiliated to the Swiss CIBA organization, is changing its name to CIBA (A.R.L.), Ltd. Formed in 1934 for research into aircraft structures, its activities have been centred mainly on the development of synthetic resin adhesives. The trade names, such as, "Aerolite," "Araldite" and "Redux" will remain unchanged.

G. & E. Bradley, Ltd., who recently completed their move from Alperton, Middx., to Electral House, Neasden Lane, London, N.W.10 (Tel.: Gladstone 0012), announce that K. Jones, formerly a director and general manager of British Communications Corporation, has joined the board. L. E. White, formerly general manager has also become a director, and is succeeded by L. H. Weall, lately with the Plessey Company.

A. Prince Industrial Products, Ltd., importers and distributors of West German domestic equipment, including Blue Spot, Akkord, Uher and Dual, have been acquired by Camp Bird Limited. John Dalgleish, chairman of the Camp Bird group, which includes Hartley-Baird, Ambassador, E-V, Duratube & Wire, and Electronic Reproducers, is now chairman of the company. Dr. Andrew Prince continues as managing director.

Atkins, Robertson & Whiteford, Ltd., of Thornliebank, Glasgow, announce their association with A. F. Stoddard & Co., Ltd., carpet manufacturers. Sir Robert A. Maclean, chairman and managing director of Stoddards, has been elected chairman of Atkins, Robertson & Whiteford, Ltd., who will continue to manufacture transformers and electronic instruments.

Audio-plan is the name of a new company formed to take over the retail sales distribution and demonstration facilities of B. K. Partners, Ltd., who will deal exclusively with the trade. The address of both companies is 229, Regent Street, London, W.1. (Tel.: Regent 7363.)

Dynatron Radio, Ltd., have recently taken occupation of their new factory and offices at St. Peter's Road, Furze Platt, Maidenhead, Berks. (Tel.: Maidenhead 5151.)

C. T. Chapman (Reproducers), Ltd., have moved their sales office from Chelsea to the works at Chapel Lane, High Wycombe, Bucks. (Tel.: High Wycombe 2474.)

Arthur's, the well-known retailers, have moved from 150, Charing Cross Road, to 125, Tottenham Court Road, London, W.1. The business, founded by Arthur Gray, has been in Charing Cross Road since the early 1920s.

The Keyswitch Company, manufacturers of relays and keyswitches, have moved to Irongate Wharf Road, Praed Street, London, W.2. (Tel.: Paddington 2231.)

Roberts' Radio.—The telephone number of Roberts' Radio, of East Molesey, Surrey, has been changed to Molesey 7474.

Racal Engineering, Ltd., of Bracknell, Berkshire, have been appointed exclusive agents in the United Kingdom for the sale of Transitron equipment manufactured by Van Norman Industries Inc., of Manchester, New Hampshire, U.S.A. Included in the Transitron range are v.h.f. and u.h.f. signal and sweep generators.

Fane Acoustics, Ltd., of Batley, Yorks., (Tel.: Batley 1578), has been formed by A. E. Falkus and D. A. Newbold for the manufacture of high-fidelity loudspeakers, etc. They have the manufacturing rights of the "Quartet" four-speaker combination.

EXPORTS

S.H.F. radio links capable of providing up to 600 telephone circuits are being supplied by Standard Telephones & Cables for the telephone service in Malaya. The main link between Singapore and Kuala Lumpur will employ four unattended repeater stations (5-watt) and there will be several spurs from the main route.

Telecommunications equipment, including the battery-operated radio-telephone "country set" for linking isolated localities to the telephone network, and Hivac subminiature valves were shown by the Automatic Telephone & Electric Company at the recent Poznan International Trade Fair. For the second successive year the company also exhibited at the Washington show of the Armed Forces Communications and Electronics Association.

Two mobile demonstration units equipped with industrial and marine gear manufactured by Kelvin & Hughes are touring Europe. Both units were at the Poznan Fair and the larger—a 9½-ton articulated vehicle carrying the industrial equipment—is making a four-month tour of Hungary, Czechoslovakia, Rumania and Yugoslavia. The smaller unit, equipped with marine gear, is visiting Polish, West German and Belgian ports.

Air traffic control consoles for installation at seven airports in the Belgian Congo have been ordered from International Aeradio Ltd.

British Electronic Centre.—Seven companies participated in the composite exhibition in the British Electronic Centre at the Hannover Fair. They were Ardente, British Electric Resistance Co., Geo. Bray, Cosmocord, E.M.I. Electronics, Gresham-Lion Group, and Painton.

U.S.A. Visit.—R. E. Burnett, general manager of Marconi Instruments Ltd., and S. G. Spooner, production manager of the company, left London on June 5th for a three weeks' tour of the U.S.A.

Uganda.—Electronics Ltd., P.O. Box 1869, Kampala, are interested in representing U.K. manufacturers of loudspeakers and microphones and tape recorders specially designed for operating from a 12-V or 6-V battery.

Transmitter for the new Jordan broadcasting station being built in Amman is to be supplied by Marconi's. The 100-kW m.w. station is due to open early next year.

***Radar Control Room.**—Marconi's have supplied three complete radar installations for the new Royal Aircraft Establishment at Bedford. In this view of the control room the two operators in the centre are at the control positions of the two 10-cm sets providing high and low long-range coverage and the operator on the right is controlling the 50-cm general surveillance radar.*

BRIMAR 6870

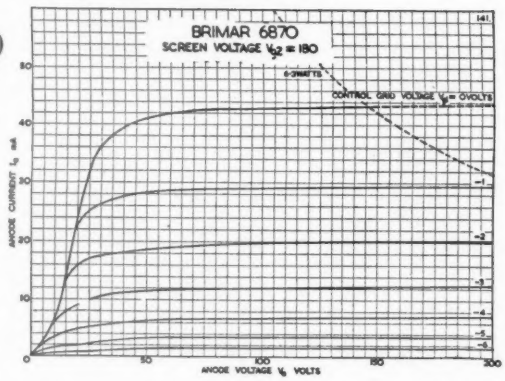
The Brimar 6870 is a Trustworthy screened pentode with a high mutual conductance and low control grid to anode capacitance, and is intended for use as a small R.F. power amplifier up to 150 Mc/s, or as a video amplifier. In the latter application advantage may be taken of the fact that the valve has higher anode dissipation and cathode current ratings than an ordinary high slope R.F. pentode, so that lower values of anode load resistance may be used for a given voltage output. This means that the valve can work into higher load capacitances without loss of bandwidth, or alternatively may be used over a wider band with a given load capacitance. The valve is fully Trustworthy and is eminently suitable for mobile equipment.

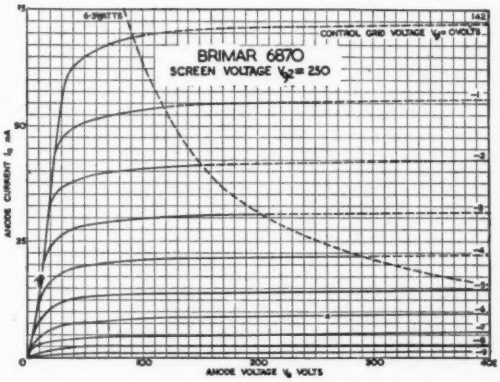
TYPICAL CHARACTERISTICS

Anode voltage	180	250 volts
Screen voltage	180	250 volts
Autobias resistor	56	120 ohms
Anode current	25	25 mA
Screen current	3.5	3.5 mA
Mutual conductance ...	9.0	8.5 mA/V
Anode impedance	170	230kilohms
Inner amplification factor (μg_1-g_2)	35	35
Control Grid Voltage for Ia=100 μA	—9	—13.5 volt

CAPACITANCES

Input	8.5 pF
Output	7.0 pF
Control Grid to Anode	0.025 pF max.





Cut this out for further reference or write to the Publicity Department at Footscray for a data sheet.

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Address .....

.....

W.W.

Standard Telephones and Cables Limited

Regd. Office. Connaught House, 63, Aldwych, London, W.C.2

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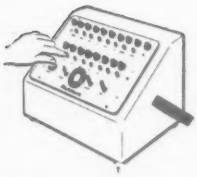

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By
H. B. DENT

Measuring Decimetric Wavelengths

Use of Resonant Lines for Calibrating an Absorption Wavemeter Covering 450 to 750Mc/s

RECENTLY the need arose to calibrate a simple absorption wavemeter for use over a frequency band of 450 to 750Mc/s, the primary purpose being to have available an unambiguous measurement of frequency in the region of 650Mc/s. The available literature contains plenty of data on the precise measurement of frequencies on u.h.f. and microwaves, but little or nothing could be found on how to achieve only a modest order of accuracy. By modest order of accuracy the writer has in mind an accuracy of one or two per cent.

There were two main reasons why only a modest order of accuracy was the target. In the first place the wavemeter is a simple "coil and condenser" type, the "condenser" admittedly being a u.h.f.

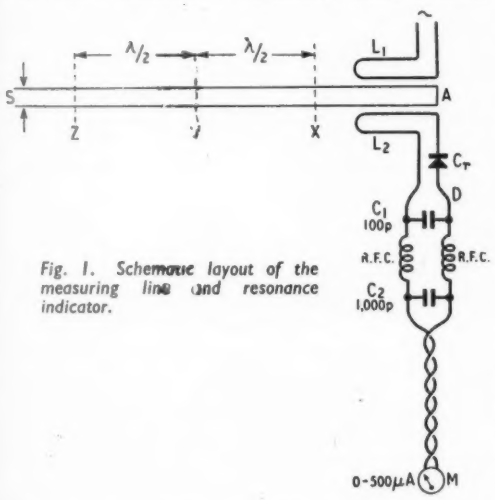


Fig. 1. Schematic layout of the measuring line and resonance indicator.

split-stator 10+10pF type, while the coil is a strip of copper 1.5in long bridging the two banks of fixed vanes. More details of the wavemeter will be given later. Secondly, the drive is an epicyclic type with a 6 to 1 reduction and a direct-reading scale of 1.75in radius is fitted, so that both tuning and reading facilities render calibration accuracy better than one or two per cent not only unnecessary but unusable.

No precision equipment was available for calibration purposes, and although a few single-frequency, crystal-controlled oscillators up to 150Mc/s could be pressed into service, initial attempts to calibrate the wavemeter with an uncalibrated variable oscillator, and relying on harmonics of the crystal-controlled oscillators to fix the frequency produced some most exciting, but utterly unrealistic, calibration curves.

The unreliability of these curves was evident from the basic fact that the ratio of the maximum and minimum frequencies covered cannot possibly be greater than the square root of the ratio of the maximum and minimum capacitances of the tuning capacitor. With a 10+10pF capacitor and with each section having a nominal minimum capacitance of 3pF the capacitance ratio, used as a split-stator component, is 5/1.5 or 3.33 to 1 and the frequency ratio cannot be greater than 1.8 to 1, while in practice it is somewhat smaller. This basic fact serves as a clue if one goes off the rails during calibration and this can quite easily happen when relying on harmonics from fixed frequency oscillators to identify the frequency.

Whilst we have come to think almost exclusively in terms of frequency in recent years a few decades ago it was the wavelength rather than the frequency one spoke about and with the utilization of the u.h.f.s for television and communications, as well as for radar, it may be more convenient once again to think in terms of wavelength. For example 10,000Mc/s, or 10kMc/s, is an unwieldy way of indicating a wavelength of 3cm. The practice of referring to microwaves in terms of centimetres or millimetres is quite common now among radar people so that many "old timers" may find themselves once again on familiar ground, or will they?

Frequency is based on a time scale while wavelength is a linear measure and provided means can be found to identify precisely two consecutive and exactly similar points on a train of waves, such as a maximum or minimum amplitude of voltage or current, then it only remains to measure this distance, preferably in metres, to find the wavelength. Standing waves on a Lecher wire system provide this condition.

If the waves are propagated in air, or by such means that the velocity of propagation is the same as in air, then knowing the wavelength it is quite easy to find the frequency, if one wants it. The relationship as everyone knows is:—

$$v = \lambda f, \text{ or } f = \frac{v}{\lambda}$$

where v=velocity of propagation in air, f=frequency, λ=wavelength.

Taking v as 3×10^8 metres a second (the same as light), if λ is in metres then f is in cycles per second. These are too unwieldy quantities to cope with when the wavelengths concerned are decimetric (and these are the only variety that

XUM

can conveniently be measured with a rule), so that it is better to take v as 3×10^4 and λ in centimetres when f becomes megacycles.

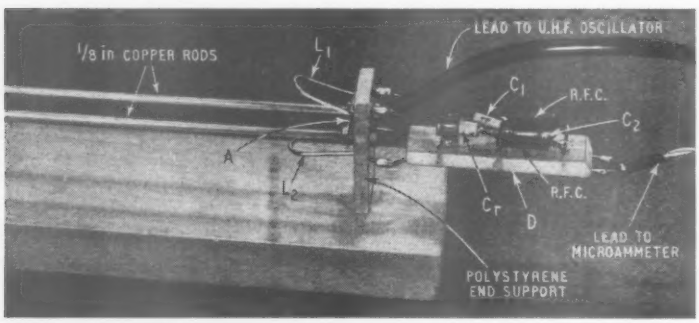
Fortunately it is easier to measure centimetric wavelengths than one might suppose provided the accuracy required is not too high. With apparatus that any keen amateur v.h.f. and u.h.f. worker can acquire reasonably cheaply an accuracy of about 1% to 1.5% in measuring wavelength is possible.

There are several ways of making the measurements but the writer favours a transmission-line method with apparatus laid out as shown in Fig. 1. Here two rigid parallel lines are laid out on a board which for the purpose in hand (450 to 750Mc/s calibration) need not be more than 4ft 6in long. The lines are made of ⅛in diameter copper rod perfectly straight and free of kinks of any kind. They are supported at intervals of about 9in on polystyrene insulators made from ¼in thick sheet and fabricated as shown in Fig. 2. This illustration shows also the method of mounting the insulators on the board and the position of the two ⅛in copper rods. The part cut away in the centre of the insulator is to leave as little as possible solid dielectric between the two rods as any quantity of this will affect the velocity of propagation of the waves on the transmission line. As it is, there is certain to be some disturbance of the velocity but with insulators fabricated as in Fig. 2 it is a minimum of the transmission line remain rigid and equi-spaced throughout their length while the shorting bar is moved along them, otherwise the accuracy of the measurements will suffer.

One end of the line is left open, as shown in Fig. 1, while the other end is short-circuited as shown at A and coupled to it are two loops, L_1 and L_2, both about 1¼in long and made of No. 16 s.w.g. copper wire. One loop is mounted above the line and the other below and spaced about ½in from it. Both the size of these loops and their coupling to the line must be adjusted to suit the particular apparatus available.

Oscillations from an uncalibrated oscillator are injected into the line via loop L_1 and a detector, D, for indicating resonance and consisting of a crystal diode, C_r, an r.f. filter and leads to a microammeter, is joined to loop L_3. A disposal plug-type radar silicon crystal diode was used for C_r but the GEX66 would no doubt be satisfactory as it is suitable for use at u.h.f. The r.f. chokes consist of 8in of No. 20 s.w.g. enamelled copper wire wound on a ⅛-in diameter mandrel with turns spaced to occupy ⅜in. The mandrel is removed of course, the chokes being self-supporting.

It is essential to work with the loosest possible coupling between loop L_1 and the line and between the loop terminating the end of the lead remote from L_1 and which is coupled to the oscillator,

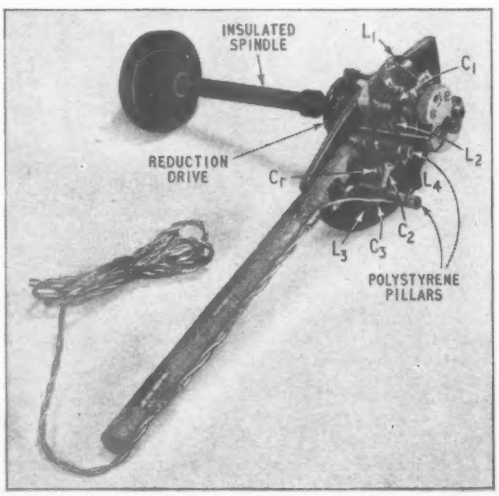


Left:—View of the transmission line used for measuring wavelength. Note the arrangement of the two loops L_1 and L_2 and the indicator D (Fig. 1).

Below:—Rear view of the wavemeter showing the arrangement of the indicator A (Fig. 5).

and does not appear to noticeably affect the measurements of wavelength.

The rods are cradled in semi-circular indentations filed in the top of the polystyrene supports and are held in position by drilling a hole through the copper rod and down into the insulator as shown in Fig. 3. The hole in the copper rod is a "tight fit" for No. 18 s.w.g. copper wire, but the hole in the polystyrene is slightly undersize. The hole in the copper is countersunk on the top face and the wire soldered in position. By inserting the end of the wire in a slightly enlarged guide to the hole in the polystyrene and applying the soldering iron to the top of the copper rod over the hole the wire will slowly sink into the polystyrene and when cold will be firmly sealed in the hole. Excess solder should be trimmed off the top face of the rod and the surface rubbed smooth and polished with very fine emery cloth. If the copper rods are perfectly straight and free of kinks it may be found that they need securing, as described and shown in Fig. 3, at every other insulator only. It is absolutely essential that the two rods



otherwise the varying loading on the oscillator caused by movement of the shorting bar along the line will affect the frequency and thus the accuracy of the measurements. Incidentally the shorting bar used consisted of a 2½-in length of No. 14 s.w.g. copper wire inserted into the end of a 4-in length of ½-in diameter insulated rod.

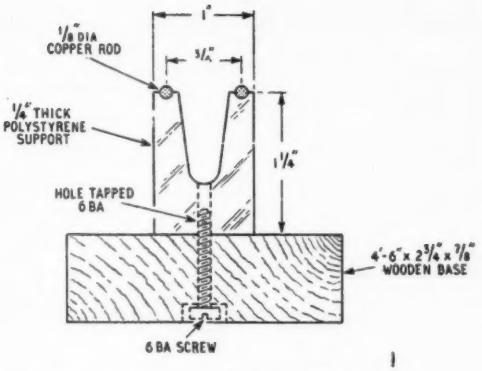
The principle of this measuring equipment is based on the fact that with standing waves on a transmission line short-circuited at one end as shown at A Fig. 1, the voltage, or current, waveform is sinusoidal reaching a maximum value and falling to a minimum value at intervals of a quarter wavelength. Thus voltage (or current) maxima will appear at intervals of a physical half wavelength if the line is wholly or mainly supported by air. A section can be said to be resonant if its physical length is any multiple of a half wavelength, thus it can be $\lambda/2$, λ, $3\lambda/2$ and so on. It behaves as a high-Q circuit so that at resonance a detector, such as D, Fig. 1, will indicate considerable r.f. voltage on the line. Quite a loose coupling suffices between the loop L_2 and the line for a working reading on the meter M. As most of the point-contact, radar-type silicon crystal diodes are easily damaged by excessive d.c. the current measured by M should never be allowed to exceed about 1.5mA. A good working level is 250μA.

Owing to the presence of the coupling loops L_1 and L_2, and the influence exerted by the external equipment connected to them, the distance measured between A and X (Fig. 1), the first position of the shorting bar indicating line resonance, is not a reliable measure of wavelength and it is necessary to move the shorting bar to the next position (Y in this case) and measure the distance X-Y. The writer gums a strip of paper along the baseboard supporting the line and marks the positions of the shorting bar on it. While the distance between X and Y will be an acceptable measurement of the wavelength, the writer prefers to take a further measurement by moving the shorting bar to the next maximum, i.e. Z, and averaging the distances X-Y-Z, or the distance X-Z can be taken as one whole wavelength.

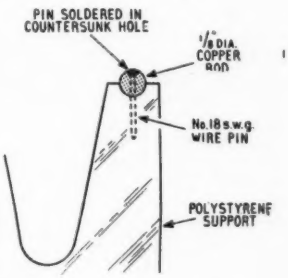
Checks with the crystal-controlled oscillators, which become possible once a reliable calibration is achieved, show that with a line spacing of ¾in the spacing cannot be ignored in the measurement of wavelength where the highest accuracy possible with this method of measurement is desired. The presence of the supporting insulators also affect the measurements slightly and it was found that half the line spacing (centre-to-centre) added to the distances X-Y or Y-Z gives quite close agreement.

Having found a simple way of measuring wavelength it now only remains to find a way of storing the information in a convenient form for practical use. This is where the absorption wavemeter comes in and for which purpose it was designed.

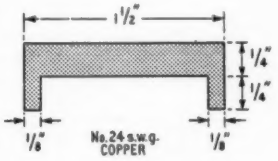
As previously stated it consists of a 10+10pF split-stator capacitor (Jackson Bros. Type C808) with a copper strip cut as shown in Fig. 4 bent into a semicircle and soldered across the two banks of fixed vanes. The small lugs at each end are to enable the strip to be soldered to both of the soldering tags provided for each set of fixed vanes. Diagramatically the measuring part of the wavemeter consists of C_1L_1 in Fig. 5. A scale, a pointer and a slow-motion drive are included, also an indicator



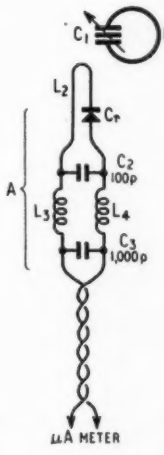
Above:—Fig. 2. Details of the insulating supports for the line and method of fixing them to the baseboard.



Right:—Fig. 3. Methods of securing the rods of the line to the insulating supports.



Above:—Fig. 4. Details of the copper strip "coil" for the absorption wavemeter.



Right:—Fig. 5. Schematic arrangement of the u.h.f. absorption wavemeter.

which can be arranged as shown at A, and which consists of a crystal diode, C_r, an r.f. filter, $C_2C_3L_3L_4$, and a pair of leads to a microammeter, exactly similar to the indicator used on the line in Fig. 1. A 0-500μA meter was used as it happened to be available, but any sensitive meter from 200μA to 1mA full scale deflection will serve. In the present case the diode C_r is a point-contact germanium type of unknown origin but the GEX66 would be quite suitable, while an alternative would be one of the radar-type crystal diodes. There are a few American plug variety radar diodes (1N21A or similar) obtainable at some surplus equipment stores and these are ideal for use on the u.h.f. bands.

The indicator portion of the wavemeter is not

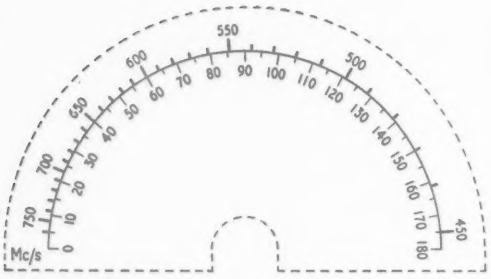


Fig. 6. The calibrated scale on the u.h.f. absorption wavemeter. The 0-180° scale can be pencilled in and rubbed out after the frequency scale is added.

required for calibrating the wavemeter as the equivalent indicator in the transmission line assembly is used for this purpose. The procedure is as follows. After locating the nodal points, indicated by X, Y and Z respectively in Fig. 1, the shorting bar is left in position at Y or Z (Fig. 1) so that the meter M is reading a maximum for the particular set-up; about 250 to 300μA as previously stated is a convenient reading. If now the " coil " of the wavemeter, L_1 in Fig. 5, is brought to within 4in or 6in of the line the needle of the meter will dip sharply when the wavemeter (L_1C_1) is tuned to the wavelength of the line. The point on the 180° wavemeter scale (described later) is recorded and the procedure repeated until ten or a dozen readings have been taken. It is very important to obtain reference points at each end of the wavemeter scale, as shown in the calibration curve Fig. 7 at 8° and 170° respectively. The wavelength measurements have here been converted to frequency.

The design of this wavemeter is a little unusual but it has been used before by the writer[1] and found to be a very convenient style. An indicator of resonance was not embodied in the earlier wavemeters as crystal diodes were unknown at that period. Another refinement embodied in the present version is the addition of a 6 to 1 reduction drive; the earlier models did not have this. Although the expression " ultra shorts " was employed in 1935 the actual wavelengths covered then were ten times longer than the present ones (*circa* 5 metres instead of 50cms), and a slow-motion drive was not found necessary.

The pointer is fixed to the epicyclic drive (Jackson Bros. Ball Drive) by drilling and tapping the slow-motion hub 6BA and inserting a $1\frac{5}{8}$-in length of brass rod which is tapped at one end and secured by a nut. The free end of this rod is shaped, by filing, into a pointer.

The scale is drawn on thick cartridge paper which, before calibrating the wavemeter, is stuck on the semicircular wooden base of the wavemeter by " Durofix " or other suitable adhesive. Initially only the 0-180° scale shown in Fig. 6 can be drawn in and, if preferred, this scale marked in pencil so that it can be rubbed out when the final calibration is transferred to the scale.

[1] "Measuring the Ultra Shorts", *Wireless World* July 12th, 1935, p.28.

Calibrating the wavemeter by means of a degree scale, drawing a curve on graph paper then transferring the measurements from the curve to the upper part of the wavemeter scale (Fig. 6) may seem a roundabout way of doing the job, but a little thought will show that it is the only way of providing a rational scale as shown in Fig. 6. It also ensures that any errors in measuring the wavelength are brought to light and either discarded or further measurements made. There are always liable to be slight errors in measurement but if reasonable care is exercised a " good fit " curve will pass through almost all the points plotted on the chart. This is seen to be the case in Fig. 7 where only one point falls wide of the curve, e.g. at 137° on the scale; something apparently went astray here and it exemplifies the advantages of the procedure outlined.

It is quite within the bounds of possibility that if a wavemeter is assembled using the same type of capacitor employed here and the " coil " cut exactly to size so that exactly $1\frac{1}{4}$in of the strip is free of the capacitor lugs, the calibration curve in Fig. 7, and the transferred calibration in Fig. 6, would be sufficiently accurate for many amateur requirements. The C808 capacitor has wide-spaced vanes, the airgaps are 0.045in, and modern production methods are sufficiently precise to ensure that the capacitances of different specimens taken at random will be in close agreement.

U.H.F. Oscillator

Nothing has been said about the u.h.f. oscillator as this is a subject not capable of being discussed adequately here. There was an article recently[2] giving details of a u.h.f. oscillator and while this is more ambitious and gives far more output power than needed here, it serves as a guide to the type of oscillator that can be used.

The writer used a single triode, an obsolete

[2] "Double Tetrode Oscillator" by J. H. Andreae and P. L. Joyce, *Wireless World* April 1958, p173.

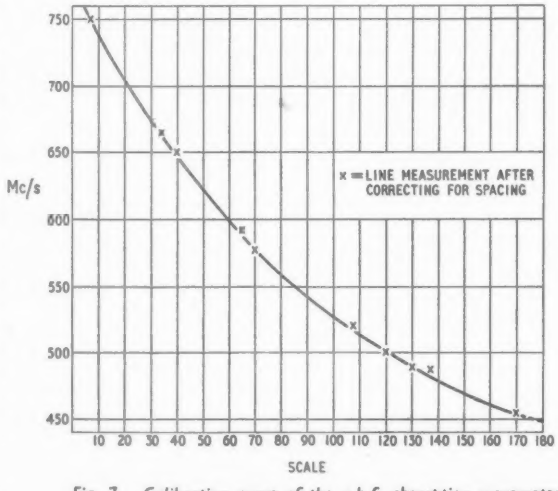


Fig. 7. Calibration curve of the u.h.f. absorption wavemeter after applying correction for spacing of the measuring line.

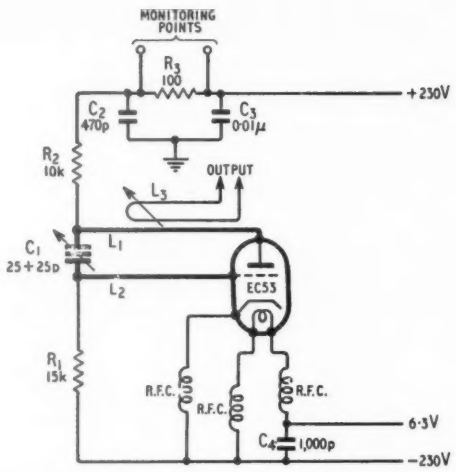


Fig. 8. Circuit of one of the u.h.f. oscillators used for the measurements.

EC53, which has anode and grid connections brought to two pins on top of the miniature glass envelope. A Colpitts-type circuit, as shown in Fig. 8, is used with the lines L_1L_2 made of $\frac{1}{8}$-in copper tube and spaced the same distance as the anode and grid pins on the valve. The valve ends of these tubes are drilled and tapped 8BA and the pins are inserted into the ends and secured by 8BA screws passing through the side of the tubes. The far end (the tubes are 2in long for the middle part of Band V) terminate at a split-stator capacitor C_1 of about 25+25pF and are soldered directly to the banks of fixed vanes.

This tuning system would not serve, even with L_1L_2 reduced to less than 1in, for the higher part of the band, but after some experiment oscillation on a spot frequency was obtained at 750Mc/s by replacing L_1 and L_2 by two copper clamps ($\frac{1}{2}$-in lengths of $\frac{1}{8}$-in diameter tube with 8BA fixing screws for grid and anode pins) across which is connected a 3-pF disc-type ceramic capacitor. The anode feed and grid-leak resistors are soldered direct to their respective copper clamps. As this is a direct short circuit, via the 3-pF capacitor across anode and grid pins of the valve it represents the highest frequency obtainable with this valve. As might be expected the r.f. output was very small at 750Mc/s, but nevertheless sufficient to give a usable reading on the line indicator. There are far more suitable triodes now available as oscillators up to 1,000Mc/s. One is the M.O.V. A2521, another the Brimar 6AF4A and a third the EC93, but the writer has not yet had an opportunity to try any of these valves in the measuring set described here.

Measuring TV Aerial Performance

On page 294 in the June 1958 issue equation 8 was given incorrectly; it should read:—

$$Z_i = \frac{Z_o\,(Z + Z_o \tanh Px)}{Z_o + Z \tanh Px}$$

Telecommunications at Gatwick Airport

GATWICK Airport—recently reopened—has much new telecommunications equipment. Two radars (which both provide moving target indication) are installed, feeding identical display units in front of each controller. The Marconi S232 is a 50cm radar and the Cossor ACR6 is a 10cm system using circular polarization to combat rain clutter. An artificially-generated video-map of the environs of the airfield is available to aid controllers on the "approach to land" phase. Instrument landing and precision approach radar facilities are also available.

A multichannel recorder (British Communications Corporation) registers the seven v.h.f. ground-to-air channels on a $\frac{1}{2}$in wide tape. Eight hours of recording is possible before the 4,800ft spool needs changing.

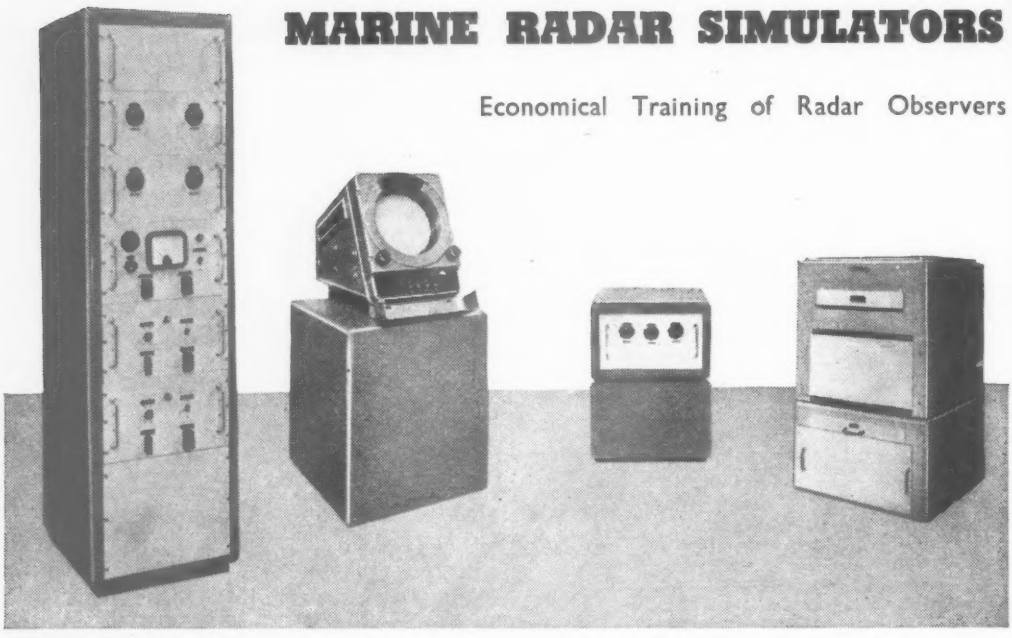
Semi-automatic teleprinter message handling is another new item. Incoming messages are stored on a magnetic drum during switching operations and until an operator is available. As soon as the operator sees the message address he presses a button automatically routing the message to its destination. The mechanism by which this is achieved is known as STRAD—Signal Transmitting, Receiving And Distribution system.

Smaller Colour TV Receiver

A colour receiver comparable in size with an existing 21-in monochrome set has been achieved by a programme of continuous circuit development at the G.E.C. Research Laboratories. It works on British N.T.S.C. type signals and uses 35 valves with a 21-in shadow-mask c.r. tube. The power pack is based on a.c./d.c. technique, with a series heater chain and a voltage doubler for the 450-V h.t. line. Seen here with the receiver are some of the members of the team responsible for its development: (left to right) E. Ribchester, P. Carnt, Dr. J. Biggs and R. Harman.

MARINE RADAR SIMULATORS

Economical Training of Radar Observers



Redifon C819 simulator. Left to right: "Other-ship" computer rack; Decca display; "own-ship" control and computer unit, and video-map generator.

"UNLESS observed by a fully trained operator, the world's best radar set is as useless to a mariner or airman as yesterday's weather report."* We would interpret that as meaning—radar can be the eyes of a ship in the hands of an operator who knows what radar can do, and, what is vastly more important, what it cannot do. Experience is essential, but experience unsupported by sound fundamental concepts is worse than useless; in fact, a man who does not understand fully the limitations of radar endangers not only his own ship; but he may put others in hazard also.

Recently the Ministry of Transport and Civil Aviation announced that for promotion to second mate (foreign-going) or mate (home waters), officers of the Mercantile Marine must possess a Certificate of Proficiency as Radar Observer to be gained by undergoing successfully two weeks' training in the use of radar.

This immediately raised a problem—how was the training to be carried out? Practical training at sea under a qualified instructor can be dismissed mainly because the number of students would be strictly limited, the cost would be too great and the students could not be allowed to learn by making mistakes.

A small, inexpensive and versatile simulator could provide the answer, and two such simulators have been developed recently by Redifon and Ultra.

Redifon C819 Radar Navigation Trainer.—This equipment consists of four units—a rack containing the computing mechanisms for producing the "other ships" and controlling their movements; a coastline generator, which produces a "video-map" of the coastline, buoys, harbour defences, etc.; an "own-ship" computer in which the manœuvres of the ship controlled by the student are computed; lastly, a display unit.

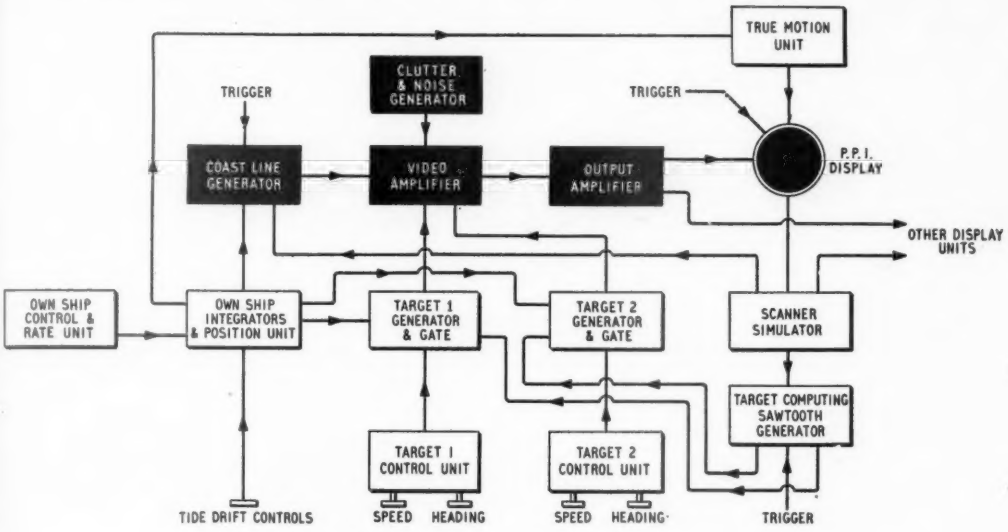
For the demonstration seen by *Wireless World* an unmodified Decca indicator with a 12-in tube was used, the main controls functioning as they would if the indicator were in use on a radar system on board ship. The true-motion unit appropriate to the indicator can be fitted, if desired, to provide training on this type of display. (True-motion is the name given to the stabilized type of display across which ships (including one's own), move with their true course and speed.)† Up to six displays can be operated under normal conditions and the manufacturers say that more can be fitted if needed.

The video-map is generated by using a flying-spot scanner displaying a radial time base to read a 2ft square photographic transparency of the coastline. The movement of own ship is simulated by moving, on a carriage, the flying-spot tube and pick-up cell over the transparency in accordance with information supplied by the own-ship computer. In this unit electronically simulated phenomena such as sea and rain clutter, receiver noise, range fall-off, etc., are added. Another facility of the coastline generator unit is the provision of a plotting board on its top which indicates, by a spot of light, the position of own ship.

When helm is applied a ship takes time to respond; also this applies to an increase in engine

* *Radar Bulletin*: Autumn 1956, p. 3.

† *Wireless World*, Vol. 62, p. 585 (Dec. 1956).



Simplified block schematic of Redifon simulator.

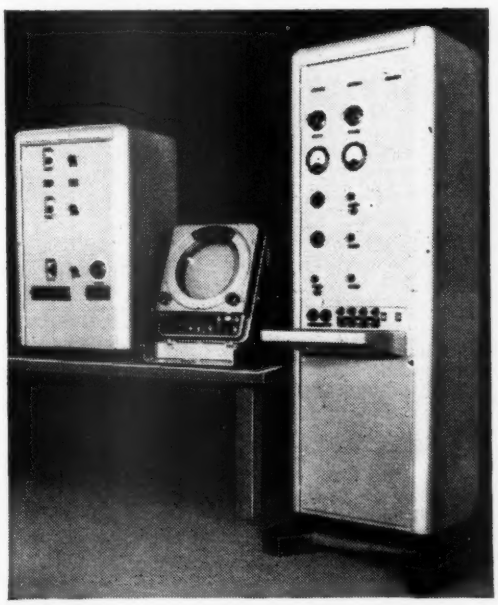
revolutions so that the own-ship unit has to compute not only course and speed; but rate-of-turn and acceleration, which can be preset to reproduce the performance of the simulated vessel. Drift of the parent ship due to tide effects can also be fed in and computed. The own-ship unit can be controlled directly by the student, by the instructor or another student acting as "helmsman." The computing actions are achieved by electro-mechanical analogue devices and the other-ship unit can generate up to six simulated ships although the basic equipment generates only two, each independently controlled and set up for course and speed by the instructor. Rate-of-turn, acceleration and tide-drift simulations are not provided on the other ships, so that new "problems" can be set up quickly.

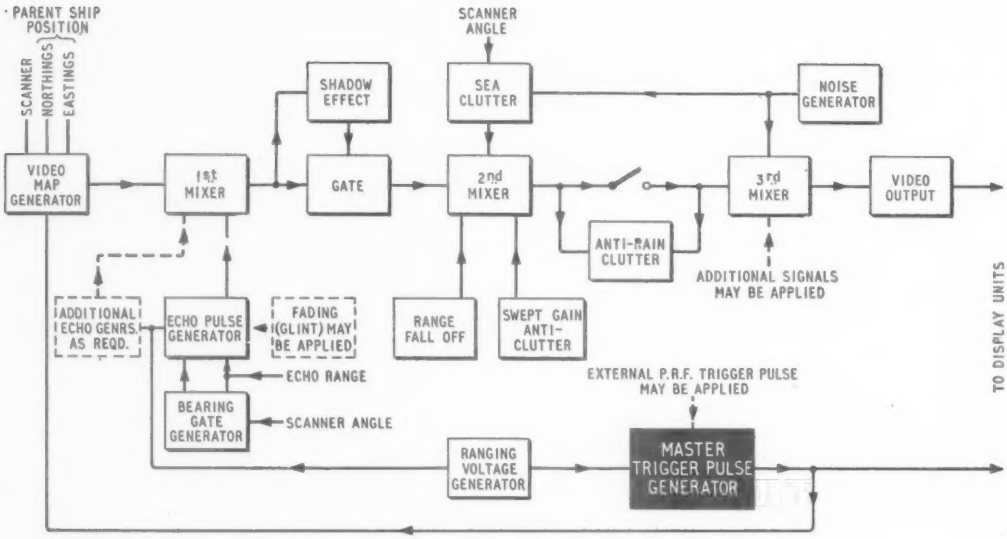
Ultra UE71 Marine Radar Simulator.—This system is built up from permutations of "standard" units (with the necessary ancillary equipment—such as power supplies, etc.) so that almost any depth of training and any number of students can be catered for. This also makes it possible to install a minimal simulator and extend it as finances permit.

The basic system consists of five units:—own-ship computer, other-ship computer, relative position data computer, "electronics" unit (which generates the video waveforms) and a true-motion unit. To these can be added a video-map generator. This basic arrangement thus provides only one other ship, but additional ships can be provided by incorporating an extra other-ship computer, position computer and electronics unit. Another important effect is possible with this equipment; namely that by using an own-ship computer in place of the other-ship computer it is possible to simulate two radar-equipped vessels on a collision course each taking independent avoiding action.

The computers are electro-mechanical analogue devices, as in the Redifon simulator. The basic "ship" outputs are in the form of northing and easting voltages which are fed to the relative position computer: this obtains the difference velocity vectors, integrates to obtain northing and easting voltages representing the position of the other ship relative to own ship, and converts these voltages

Ultra UE71 simulator. Left to right: "Own-ship" and true-motion computer; Decca display, and control rack containing "other-ship" computer, relative position data computer and electronics unit. The video-map generator is not shown.





Block schematic of video chain of Ultra simulator.

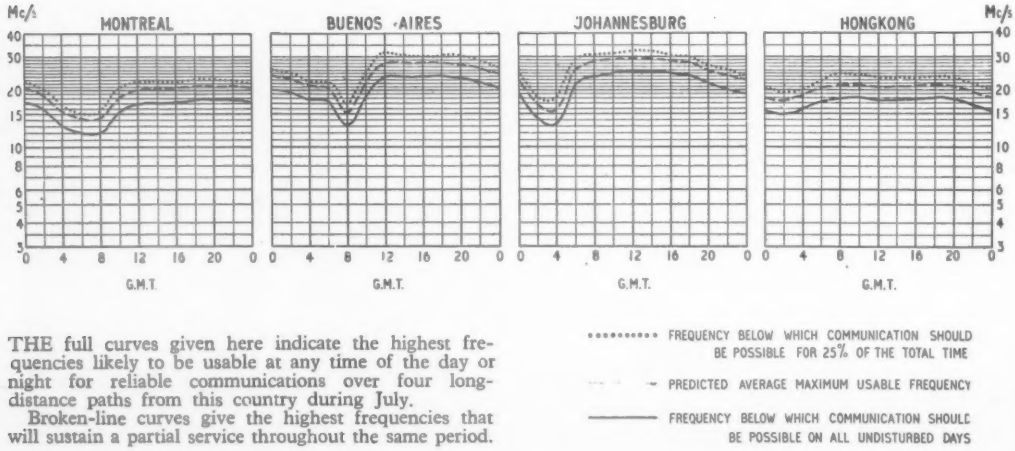
into range and bearing information. This is fed to the electronics unit which generates the pulse to simulate the other ship on the p.p.i. and, for own ship, sea clutter, receiver noise, range fall-off and shadowing.

The flying-spot scanner which produces the video-map does not rely on mechanical movement for simulation of own-ship movement. Instead, this is accomplished by using a small slide (1½in diameter) and deflecting the radial scan over the face of the flying-spot tube. The video-map generator has a picture element discrimination of better than 50 yards (i.e. roughly equivalent to a 0.3μsec pulse length) over a map area of 625 square miles.

The display unit can be any display in current use, but the equipment is designed to work with an unmodified Decca indicator, the main controls functioning as in a shipborne installation. Ultra incorporate their own true-motion unit which enables them to integrate the true-motion display with the rest of the simulator more easily.

SHORT-WAVE CONDITIONS

Prediction for July



THE full curves given here indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during July.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

These sub-miniature coaxial plugs and sockets have been designed to meet the mounting requirements for small coaxial connectors brought about by the increase in the development and use of miniaturized equipment.

The plugs are securely retained by a knurled nut which screws on to a thread on the socket. A rubber washer is fitted at the junction of this thread with the fixing flange, to prevent loosening of the knurled nut by vibration.

P.T.F.E. (poly tetrafluorethylene) insulation is used, ensuring low high-frequency losses, and a high maximum working temperature.

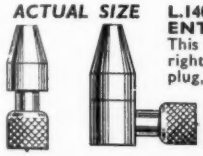
All contact surfaces are gold-plated for low resistance connection and to prevent corrosion on the centre pin, where the contact area is fairly small.

The plugs are suitable for use with coaxial cable having outside diameter of $\frac{1}{8}$" approx. (e.g. 50 ohm sub-miniature coaxial cable B.I.C.C., No. R.P.C. 1373).

These components and other new developments are fully described in the Supplement to our General Catalogue: copies are available on request.

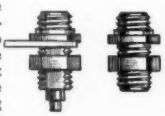
L.1403/FP. FREE PLUG.
The cable to this plug enters along the axis of the plug. The rubber cover protects the cable clamp from damage and gives the plug a streamlined appearance.

ACTUAL SIZE



L.1403/RFP. RIGHT ANGLE ENTRY FREE PLUG.
This plug has the cable entry at right angles to the axis of the plug, enabling the cables to be "dressed-down" against a panel without the danger of sharp bends causing cable failure.

L.1403/CS. CHASSIS MOUNTING SOCKET.
This socket is designed for use where the feeder enters equipment, and is not required to continue as a coaxial cable as the components associated with it are in close proximity to the socket. It is fitted with soldering tags which are gold-plated for ease of soldering.



L.1403/BS. BULKHEAD ADAPTOR.
This socket-to-socket panel mounting adaptor provides for the passage of a coaxial cable through a panel, in such a way that the cable can be disconnected on either side. It is ideal for use where a coaxial lead needs to be continued behind the main panel of equipment.

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"BELLING-LEE" NOTES

Chillerton Down is in radio news now. The pilot transmitter has been radiating since April 28th, and in general is being well received within its limits. The pilot aerial is on a "Belling-Lee" short "Skytower" which means that it cannot "see" over the Rowridge site to Bournemouth, so that busy centre of population has a weak signal calling for a high gain receiving aerial in most places.

From letters received, it is obviously necessary to repeat that although there may be sites where the I.T.A. signal can be received on a B.B.C. aerial, this is bad practice, and if it doesn't work don't blame I.T.A. Incidentally, the greater the number of elements in the B.B.C. aerial the worse it will be for I.T.A. The more complex the array, the greater the confusion when used off frequency. Apart from loss of gain, the polar diagram is upset, and with certain frequency combinations the aerial works better back to front.

Readers in the Chillerton Down area should read the latest "Belling-Lee" Bulletin which has features specially written for the area.

The pilot transmitter coverage continues to surprise us. We did not expect it to be received much East of Chichester, but it has been measured in Brighton by our own mobile research unit and confirmed by I.T.A. This does not mean that everybody in Brighton will receive a picture from the pilot, but it seems probable that most parts of Brighton will get a generally good picture from the main transmitter radiating from its 750 foot mast as against the band I signal from a 450 foot mast; at least a double six or a 9 element array will be required.

N.E. ENGLAND T.T.T.

Burnhope will be the next I.T.A. transmitter: our guess is a pilot signal in the Autumn. It is generally known that the frequency is channel 8 as Lichfield, but horizontally polarised. Aerials have been available for some time. Whilst there will not be much difficulty in the signal reaching the main centres on Tyneside and Teesside, there will be locations in the hills where great care will have to be taken to obtain a good picture without waste of money.

Advertisement of
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Written 19th April, 1958

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M.3

LETTERS TO THE EDITOR

The Editor does not necessarily endorse the opinions expressed by his correspondents.

Direct-coupled Transistor Amplifier

ALTHOUGH, as Mr. Tait has kindly acknowledged in his article in the May issue, I did discuss during the course of an I.E.E. meeting the possibility of such direct coupling techniques, the idea was originally proposed by Dr. G. B. B. Chaplin (Patent Appln. No. 32013/56). The basic principle has, in fact, a wide range of application apart from that mentioned above.

Having examined Mr. Tait's version of the amplifier in detail it appears that, unfortunately, his design is extremely temperature-dependent, as, indeed, he admits. The reason for this lies in the temperature sensitivity of the leakage current i_{co} of the input transistor. As is well known, i_{co} for a germanium transistor is doubled by a 7°C rise in temperature. Thus, considering the OC71 input transistor, a typical value for i_{co} of 3 μA at 20C° becomes 6 μA at 27°C, 12 μA at 34°C, 24 μA at 41°C, and so on (Ref. 1). Since the d.c. stabilizing feedback resistance connected from the output collector to the input base (Fig 2 of Mr. Tait's article) is given the high value of 1MΩ, the change in output collector voltage level for a temperature change of only 7°C (from 20°C to 27°C) is 1MΩ×3 μA=3V. A further rise in temperature, or the use of a transistor whose i_{co} happens to be on the high side, would render the amplifier inoperative due to the output transistor becoming bottomed.

However, the problem is easily solved by reducing the d.c. feedback resistance to about 10kΩ, which means that the shift in output d.c. level under the above conditions is now only 10kΩ×3 μA=30 mV. The feedback can be rendered inoperative for signal frequencies by splitting the 10kΩ resistance into two 4.7kΩ units and shunting the centre point to earth with a suitably large decoupling condenser. (A low voltage electrolytic is satisfactory as it has never more than about 0.5V across it.) (Fig. A.)

With the above arrangement the output collector voltage is very nearly at earth level due to the low value of feedback resistance. Three volts or more is required to bias the output collector into the operating region, so that reasonable voltage swings may be obtained. This may be carried out by means of a current bleed I into the feedback network. If the output level is required to be 3V then the value of I is readily determined from the value of the feedback resistor into which it flows.

Thus in the present instance $I = \frac{3V}{4.7k\Omega} = 0.6$ mA. This method gives the designer considerable freedom in choosing, for example, the d.c. load resistance, and the voltage of his battery supplies, since the biasing is now completely defined by feedback and is sensibly independent of transistor parameters.

Negative feedback at signal frequencies may now be applied (a) by bridging the d.c. feedback network with a suitable resistor (Mr. Tait uses the range of values 100kΩ to 1MΩ) or (b) by inserting a small resistance in series with the decoupling capacitor (see Ref. 2 for the limitations of this method) or, preferably, (c) by arranging local feedback loops within the main d.c. feedback loop (Ref. 3). This allows greater latitude in the choice of feedback factors and also allows more feedback to be applied without giving rise to the peak in h.f. response which Mr. Tait obtained with 17 dB of feedback.

Very high stable gains are available using these techniques. As an example, two versions of this circuit, described in Ref. 3 and shown in Figs. B and C, have

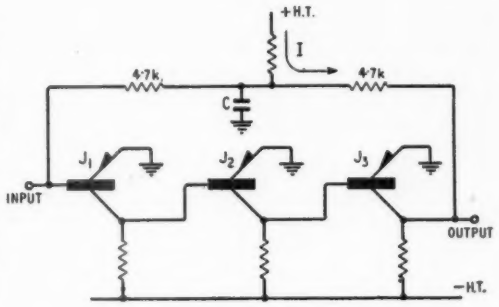

Fig. A.

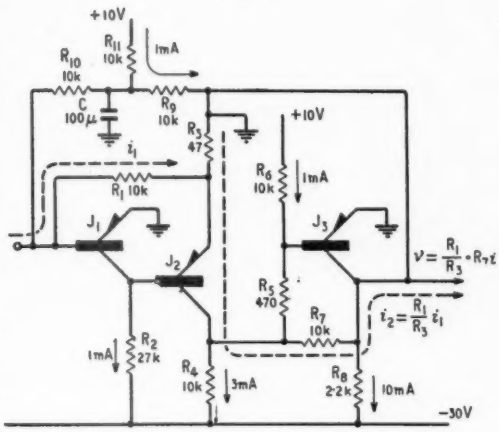

Fig. B.

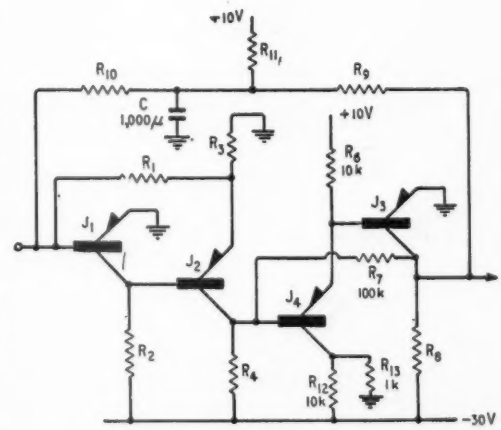

Fig. C.

stable gains of 2V and 20V output respectively for 1 μA of input current, with a bandwidth in each case extending from 60 c/s to 30 kc/s.

Harwell. A. R. OWENS.

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2. Almond & Boothroyd: "Broadband Transistor Feedback Amplifiers," *Proc. I.E.E.*, Jan. 1956, Part B, p. 93.
3. Chaplin & Owens: "A Transistor High Gain Chopper Type D.C. Amplifier," *Proc. I.E.E.*, May 1958, Part B, p. 258.

Suppressing Television "Bright Spot"

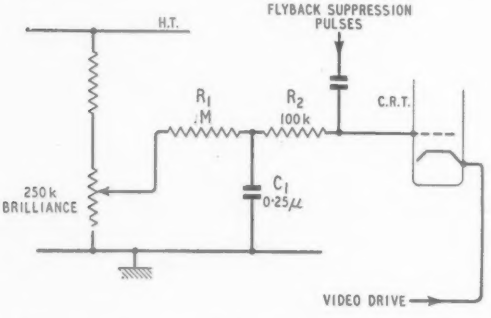
I WOULD like to make one or two comments on Mr. E. Moston Kenny's article in the March issue of this journal.

He states that the television set should not be switched on for several minutes after being switched off, with which I agree, although in practice this can—and does—happen. The system proposed is based upon not allowing the tube to conduct after switch-off has taken place, resulting in the e.h.t. being at maximum value with no method of discharge except through the leakage of the e.h.t. capacitor or through a bleeder resistor across the capacitor. Owing to its very function in life, the e.h.t. capacitor normally has an exceptionally high dielectric resistance and very few sets are fitted with bleeder resistors. This results in the e.h.t. remaining on the tube for some considerable length of time. On one set tested, the e.h.t. decayed by only 25 per cent after 15 minutes.

The second feature of the system which I find undesirable is the fact that the grid is not only not decoupled, but hum is actually fed on to it from the h.t. supply via C_1. Additionally, the system would seem to preclude the possibility of using the grid for the application of flyback suppression pulses.

A third point is that the mains switch is coupled to the brilliance control, resulting in the user having to wait until the picture appears before being able to adjust the brilliance level. With the mains switch coupled to the volume control, the user quickly gets used to rotating the control approximately to the position required but, whilst the ear can readily adjust itself to some variation of volume, the eye is not so accommodating.

In brief, as I see it, the system has many disadvantages



which are not apparent if the e.h.t. is made to discharge as the h.t. collapses. This can be done easily and simply at no greater cost than that of the scheme proposed by Mr. Kenny. One such method which has been used on production receivers for several years is shown in the diagram.

On switching off the receiver, the grid voltage—due to the time constant C_1R_1—collapses at a slightly slower rate than the e.h.t., thus maintaining the tube beam current during the collapse of the line scan and discharging the e.h.t. to such an extent that the bright spot does not appear. The tube grid is prevented from going appreciably positive by R_2 but if grid current does flow the voltage across C_1 decays at an even greater rate.

This scheme will, of course, fail if the brightness control is turned to zero. This, however, does not happen in practice, since it would mean a hopelessly over-contrasted picture. One criticism which may be levelled at it is, however, the fact that adjustment of the brilliance control is not immediately followed by change of brilliance on the screen, due to the time constant R_1C_1. However, the values shown give a time constant of $\frac{1}{4}$-second and this has been found not to be of such length as to be objectionable.

BRIAN G. SCOTT,
Peto Scott Electrical Instruments, Ltd.

Weybridge.

Why Valves?

IN your June issue "Diallist" falls into the common error of supposing that the word "valve" means only a one-way device. If he refers to the Concise Oxford Dictionary he will find that the word means more than this, for it also describes a device for controlling the flow of liquid, etc.

A steam valve, for instance, is not necessarily merely on or off, it is used for the precise regulation of the quantity of steam, as in a throttle valve.

I submit, therefore, that so far from being wrong, "valve" is the only correct word for thermionic devices. In the radio valve the passage of a current is precisely controlled in magnitude by the adjustment of the grid voltage. This is exactly analogous to a throttle valve which, by the mechanical adjustment of an obstruction in a passageway controls precisely the magnitude of flow of steam, air, liquid, etc.

Ewell, Surrey. W. T. COCKING.

I SUGGEST that "Dialist" is thinking possibly of valves in an engine or pump when he discusses this mechanico-electric analogy. In this case the glove fits the hand well for a diode but would seem off the mark for an amplifier pentode, etc.

However, if the full application of the word valve is considered we see that it also refers to devices such as throttle valves, needle valves and gate valves.

The first two types surely "modulate" the flow of a current in a fluid while the last acts as an electronic switch giving the familiar "cut off" beloved in radar technology.

By comparison the French term is definitely démodé, while the American is blatantly superficial. Let us therefore rather congratulate ourselves on this logical development of our language.

Oxford. I. G. HOLT.

Reconditioned CR Tubes

I REFER to "Diallist's" remarks on the subject of rehabilitating cathode ray tubes. Some six months ago I fitted one of these "rebuilt" tubes into a friend's television receiver and found that its performance was—and indeed still is—in every respect equal to that of a new tube. The only difference, of course, being the price, which was one-third of that of the new article.

Like "Diallist" I too cannot see why a properly rebuilt tube should not be perfectly satisfactory, and the fact that the "rebuilders" give a full six months' written guarantee, surely confirms their own confidence in their methods, as well as safeguarding the customer.

It is to be hoped that the advent of such a process will also have the effect of reducing the exorbitant prices now charged for new tubes.

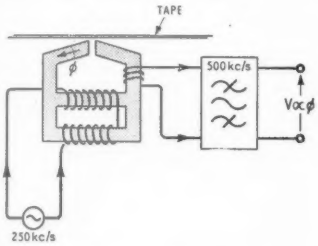
London, S.E.5. L. D. KITCHEN.

Variable-Output Mains Transformer.—In Fig. 2 on page 263 of the June issue the 2V bulb should be connected directly to the 1V winding, not via the switch as shown. Also the output markings L and N should be transposed.

XUM

Technical Notebook

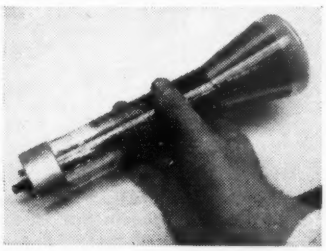
Flux Sensitive Heads for playback in data magnetic-tape recording systems have been developed by the M.S.S. Recording Company. Normally, of course, the output of a conventional playback head is dependent on the rate-of-change of the recorded flux and falls at 6dB per octave with decreasing frequency. This makes it very difficult to use conventional heads for certain data recording applications involving very low frequencies, since the output signal amplitude can fall to little more than the noise level. Hence the need for a head which responds to the actual value of the flux and not its rate of change. The principle of the M.S.S. design is similar to that of the head developed by E. D. Daniel (see November, 1955, issue, p. 562). The flux from the tape is caused to modulate a supersonic frequency flux produced by a winding on the



head, and the resultant product is picked up by a search coil. The supersonic flux itself does not appear across the head gap by virtue of the winding being arranged in two mutually opposing halves. A supersonic frequency up to 250kc/s can be used, and at this frequency the output from the head when in contact with a saturated tape is 10mV r.m.s. A maximum signal/noise ratio of about 50dB can be obtained over a large range of wavelengths. The heads in production have a track width and track spacing of 0.03in with a gap length of 0.005in. These dimensions give four tracks on ¼-inch tape or eight on ½-inch tape. Driving power of about 5mW per track is required, while the impedance of the windings is 1.5Ω at 100kc/s.

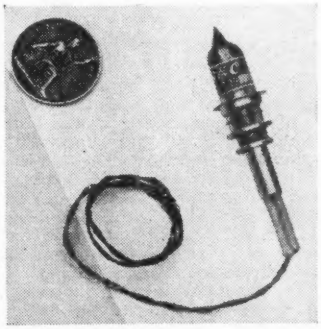
One-c/s Klystron analogue devised by the G.E.C. Research Laboratories in order to give a simple picture of bunching processes uses a rotating glass tube with its axis horizontal, apart from two short lengths between bends. Ball bearings injected into the tube are velocity modulated at the short non-horizontal portions at a frequency of about 1c/s by the rotation. The level part of the tube between the two non-horizontal portions provides a first drift space about 2ft long, at the end of which some bunching of the ball bearings can be seen. The second non-horizontal portion is placed at the right distance to give additional modulation. This produces almost perfect bunching at the end of a rather longer (4ft) drift space; the ball bearings being ejected in groups of three.

Battery C.R.O. Tube, suitable for operation from a transistor d.c. con-



verter and mentioned in the May, 1958, issue (p. 220), is shown above. Made by Electronic Tubes, it requires an h.t. voltage of only 1,000 volts and has a heater consumption of 1 watt.

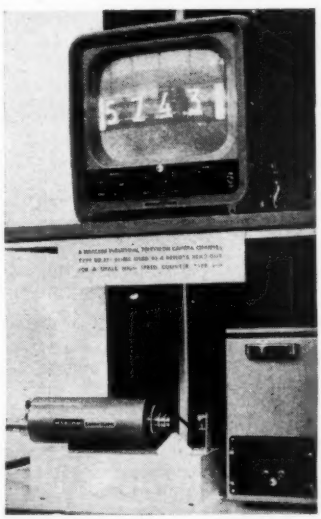
U.H.F. Triode of the disc-seal type, capable of giving the high output of 2 watts at 4,000Mc/s, is shown in the illustration below. Made by



G.E.C., it is practically subminiature in size and is conduction cooled. The mutual conductance (static) is 14mA/V and the maximum operating frequency 6,000Mc/s.

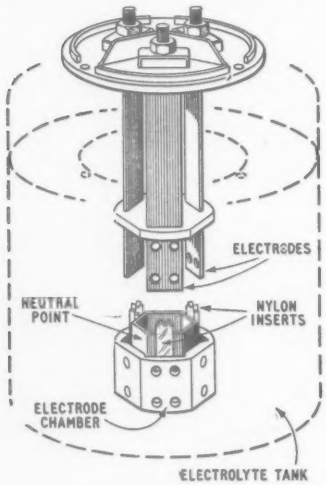
Shirt Button Size high-temperature triodes, produced in prototype by General Electric of America and described in the 28th March, 1958, issue of *Electronics (Engineering Edition)*, use no heaters as the designed ambient operating temperature (about 700°C) is sufficient to produce emission from the cathode directly. These metal and ceramic valves can operate up to at least 1,200Mc/s.

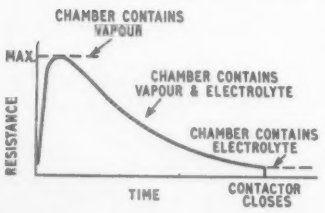
Automatic Sensitivity Control is a feature of a small industrial television camera which Marconi's have recently introduced for closed-circuit applications. This automatic system compensates for wide variations of lighting levels and allows the equipment to operate completely unattended. The camera unit itself is a small steel cylinder 4 inches in diameter and 11 inches long, containing a 1-inch photoconductive pick-up tube with its scanning coils and head amplifier. The camera control equipment is a separate unit and contains the final video amplifier, scanning circuits, scan protection system, power supplies and all operational controls except optical focus, which is at the rear of the camera. Scanning standards can be either British, American or C.C.I.R., and a random interlaced picture is produced unless an external synchronizing source is utilized. The illustration shows the camera (bottom



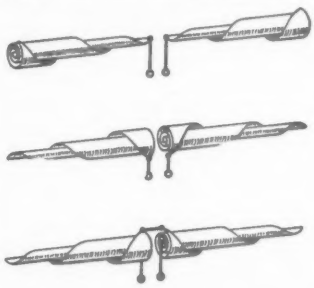
left) in a demonstration for remote viewing of a high speed counter made by Counting Instruments. The numerical display can be seen on the monitor screen above.

Vapour Motor Starter for slip-ring motors is an automatic rheostat which gives a smooth change of resistance, as distinct from the conventional stepped-resistance starter, and so obtains smoother acceleration and protects the motor from mechanical shocks. It is smaller and cheaper than conventional starters of equal capacity. Devised by M. Berard of the French company Association des Ouvriers en Instruments de Precision, the rheostat depends on the great difference in resistance between a liquid electrolyte and its vapour (of the order of 1:50). It consists of a three-phase electrode system (see sketch) carrying the rotor current of the motor, contained in a perforated Steatite chamber and immersed in a tank of electrolyte. The initial high current on switching on heats the electrolyte in the space between each electrode and the neutral point and vaporizes it almost instantaneously. This gives the initial high resistance shown in the graph. As the motor accelerates, the rotor current gradually diminishes, so that the rate of vaporisation is decreased and the electrolyte tends to return progressively into the Steatite chamber. The resistance, which depends on the ratio of liquid to vapour in the chamber, is therefore reduced in proportion to the rotor current, as shown by the falling part of the graph. Eventually the electrode chamber is filled with electrolyte once again and the conductivity of this is sufficient to carry the full-load rotor current. At this point, when the resistance is at its minimum, a contactor is brought into action by a simple thermistor timer and short-circuits the whole rheostat so that it is taken out of the motor circuit. Nylon inserts are put in the electrode chamber (as shown in the diagram) to regulate the effective area of the electrodes and the volume of the vapour spaces according to the starting conditions of the motor. The equipment is being manufactured in Great Britain by Lee Guinness of Northern Ireland.





Rolled Triangle Aerials described by J. R. McDougal, S. Adachi and Y. Mushiake in the *Reports of the Research Institute of Electrical Communication, Tôhoku University* (Japan), Vol. 8, No. 3, 1956, consist of triangular sheets of metal rolled up into the spiral forms shown in the sketch. The first type is fed from the apexes of the triangles, the second from the spirals at the larger ends, while the third is a folded dipole fed from the origins of the spirals. In the unrolled state these aerials resemble fan or butterfly types, and the main object of the



Tôhoku University work has been to retain the wide-band characteristics of the fan aerial while improving its mechanical stability. The measured impedance curves indicate that wide-band operation is best when the aerial is used as a full wavelength dipole. When used as a half-wave dipole its behaviour is similar to that of an ordinary cylindrical dipole, except that it gives a marked increase in electrical length—making possible half-wave dipoles of short physical length. In general the radiation patterns of the rolled-triangle aerials have the familiar figure-of-eight look associated with half-wave dipoles, however, there is one important difference—they retain this characteristic well past the frequency where the aerial length is equal to one wavelength.

H.F. Power Transistor, the device we have all been waiting for, has now appeared in the lists of two manufacturers. Hitherto, of course, the geometry of the electrodes of the average power transistor has made operation at high frequencies impossible. Now Mullard have the type 1520C and Newmarket the types V15/20IP and V30/20IP (for different collector voltages), and both makes are said to be capable of providing an r.f. output of 3 watts at 500kc/s.

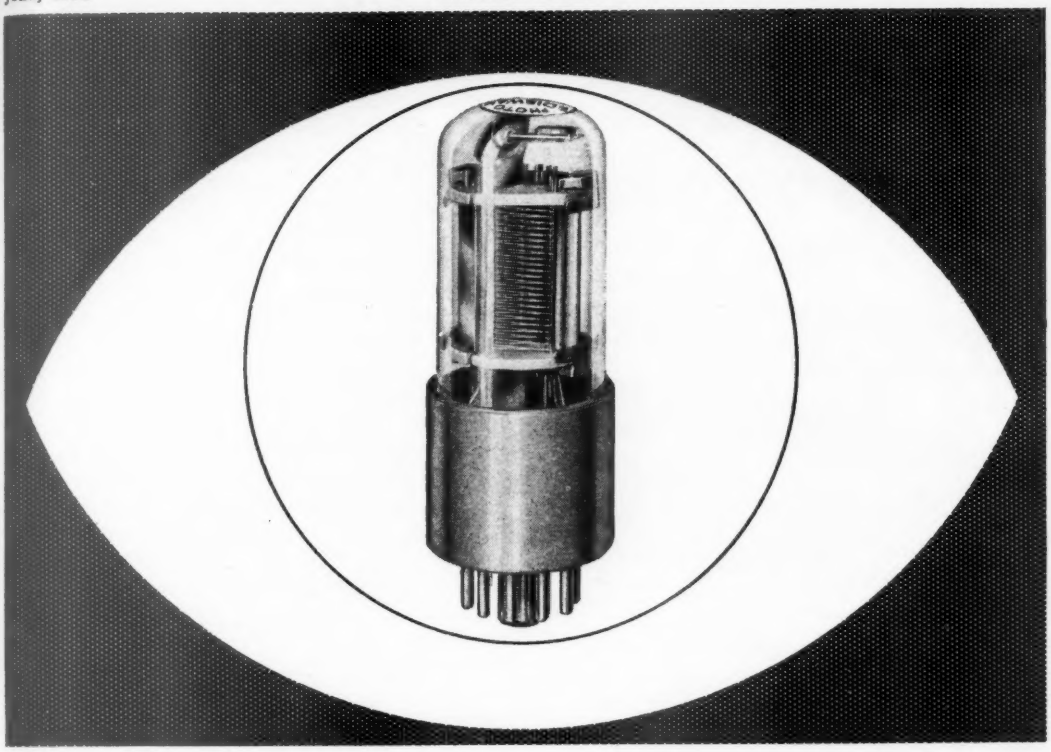
Crystals for Masers.—The Royal Radar Establishment are concentrating work on the solid-state maser having a paramagnetic impurity suspended in a regular dia- or non-magnetic crystal structure. Large crystals are required, since the technique used is to cut the crystal into suitable shapes for insertion into a resonant cavity or waveguide. The two main substances in use are gadolinium ethyl sulphate and potassium chromicyanide in a high degree of dilution as a solid solution in alum, which possess a suitable type of crystal structure.

In preparation a saturated solution of the salts required is made, and its temperature is allowed to drop at a rate depending on the solubility of the salt, the surface area of the crystal and the volume of the solution. The temperature is maintained to within 0.05°C of its correct value over 10 to 14 days. In this solution is placed a small "seed" crystal. Growth starts and is continued until a specimen of sufficient size has been produced. To ensure regular growth the crystal is kept moving in the solution.

Ice Crevasse Detector using four shallow dish-shaped electrodes attached in front of a vehicle is described in *Electronics* (*Engineering Edition*) for 17th January, 1958. Two of the electrodes are fed with a signal at about 150c/s. The field between the other two electrodes due to this signal is amplified and fed to an alarm system. When a crevasse is approached, it alters the field and sets off the alarm. If the detecting electrodes are on an equipotential of the field, crevasses which are parallel to this equipotential will not be detected. This possibility is avoided by using an asymmetrical electrode arrangement.

Turntable Driven Tape transport and record/replay mechanism (the 'Gramdeck") is marketed by Stevenage Tools and Switches. The tape speed is 7½in/sec for a gramophone turntable speed of 78 r.p.m. Equalization and high-frequency bias are provided by a three-transistor battery circuit. Signals on the tape are normally erased by a permanent magnet.

XUM



Announcing
two new EDISWAN Photomultipliers

We are pleased to announce two new Ediswan Photomultipliers : Type 27 M12 and Type 27 M13.
Both are based on the well-known Ediswan Photomultiplier Type 27 M1.
Here are brief details of the new types (further particulars will be gladly given on request) :

27 M12		27 M13	
Nine-stage Photomultiplier specially designed for use in aircraft and other locations where strong vibration is experienced.		Seven-stage Photomultiplier with twin anodes. These provide a double output, which remains well matched under all conditions.	
Base:	Flying Lead	*Base:*	11 pin sub-magnal
Cathode:	Blue Sensitive	*Cathode:*	Blue sensitive
Av. Cathode Sensitivity:	20 μA/lumen	*Av. Cathode Sensitivity:*	15 μA/lumen
Max. Anode Current:	1 mA	*Max. Anode Current:*	1 mA
Typical Operation:		*Typical Operation:*	
Volts per stage	65V	Volts per stage	125V
Volts anode to secondary cathode	65V	Volts anode to secondary cathode	50V
Sensitivity (white light)	1.0 A/lumen	Sensitivity (white light)	2·0 A/lumen
Average Current Amplification	60,000	Average Current Amplification	13,000
List Price: £18.0.0		*List Price:* £16.0.0	

Other Photomultipliers in the Ediswan range.

27 M1 Standard high sensitivity type (9 stage)	List price £15.0.0.
27 M2 Lower sensitivity (9 stage) type	List price £ 8.0.0.
27 M3 Sensitive to near ultra violet (9 stage)	List price £16.0.0.

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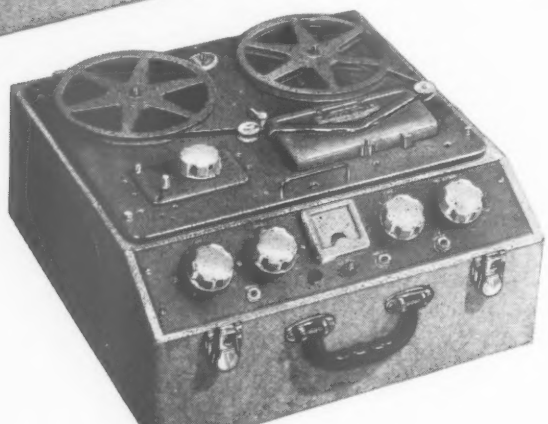
A LOGICAL APPROACH TO Stereo sound

To satisfy the growing interest in stereophonic sound, we introduced at the Audio Fair a new Ferrograph Series 3S fitted with an additional "in line" (or stacked) head and the Stere-ad Unit—

—both of which are illustrated here.

The Series 3S incorporates all the basic features of Ferrograph design and, of course, functions as a normal monaural recorder and reproducer. But, at any later date, it can also play commercial or other stereophonic tapes (recorded by the stacked head process) by the attachment of an additional unit designated the Stere-ad. Essentially the Stere-ad Unit incorporates two matched pre-amplifiers (one for each track) together with a second $2\frac{1}{2}$ watts power amplifier. Connecting the Stere-ad Unit to the Ferrograph 3S completes the connections whereby the two pre-amplifiers and the two power amplifiers (one already in the Ferrograph and the other in the Stere-ad) automatically provide a $2 \times 2\frac{1}{2}$ watts matched stereophonic output for feeding into any appropriate external speaker system.

This logical approach to the problem will permit the owner of a Ferrograph 3S to enjoy all the thrills of true stereophonic sound at any future time at small cost without discarding any existing equipment.



In two models in cabinets covered light grained rexine, with bronze deck and control panels and cream fittings, as follows:

MODEL 3 S/N
$3\frac{3}{4}/7\frac{1}{2}$ i.p.s.
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Long-distance H/F Broadcasting

FACTORS GOVERNING EFFECTIVE COVERAGE OF TARGET AREA

By T. W. BENNINGTON*

PERHAPS the most important factor in ensuring good broadcast coverage of a distant target area, where the transmissions are by ionospheric propagation of the radio wave, is the correct choice of working frequency to suit the time of day, season of year, phase of the sunspot cycle and length and geographical disposition of the transmission path. The complex variables which govern this have been the subject of much study over the past three decades, and considerable progress has been made, which is not to say that the problem has, as yet, been completely solved. Nor is this surprising when one considered the complex nature of the ionosphere and the fact that, concurrently with our exploitation of it as a transmission medium, our knowledge of its physical characteristics has been, and still is, slowly advancing.

In this article, however, we turn to another problem which is of great importance in ensuring good coverage; that of "directing" the transmitted energy towards the ionosphere in such a manner that the distant target area is most efficiently "illuminated." Unless this is done power will be wasted—that much is obvious. What may not be so apparent are the facts that this subject itself

Fig. 1. Triangular-ray paths between transmitter and the target area.

is, like that of the correct choice of working frequency, bedevilled by an imperfect knowledge about the precise transmission mechanism which is operative under all conditions, and by the necessity for continual compromise in order to allow for changes in the ionospheric parameters involved.

Before describing the problem and detailing the methods by which its solution has been, and at present is being, attempted it must be remarked that work is going on at the D.S.I.R. Radio Research Station, Slough, which aims to determine the precise trajectories of transmitted waves at given times over given paths[1], and so to learn more about the transmission mechanism which can be directly applied to improving the present methods. However, this article will be confined to the application to h.f. broadcasting of the methods at present in use, and will not include anything of this new work, the results of which are not yet available.

The General Problem.—The "illumination" provided over a distant target area depends, in the first instance, upon the geometry of the earth/ionosphere transmission path and upon the azimuthal and vertical radiation patterns of the transmitting aerial system. Best coverage will result when the latter is such as to excite most strongly those ray paths which, under all ionospheric conditions, produce the strongest field at all points across the target area. In the case of one-hop transmission this is a relatively simple matter, but our remarks here will be confined to the coverage of target areas lying beyond the region that can be reached by one hop of the wave between earth and ionosphere, i.e. where the near boundary of the area is distant greater than about 4,000km from the transmitting station.

In the method to be described the paths of the rays which cover the area are assumed to be those obtained from the geometry of triangular paths between earth and the virtual height of the reflecting layer, assuming a spherical ionosphere and earth. An example is given in Fig.1, where, for the sake of clarity, only two ray paths are shown. In fact these virtual heights, even assuming F_2-layer propagation only, vary constantly with time of day and season and, since this means that they may vary all along a given transmission path, hops of unequal length may result for the various rays. Moreover, the idea of triangular paths of equal length is only, of course, a convenient assumption, because the actual curved apex trajectories may vary with the different electron distributions at the different ionospheric locations. Again, although the assumption that F_2-layer propagation predominates in multi-hop transmission is true enough, it is known that at certain seasons and at certain geographical locations at some times of day Sporadic E propagation may occur, in which case the trajectories are drastically altered.

In short, the actual trajectories of many rays traversing a long path involving many hops and with a changing ionosphere may be very complicated, and even if full details of this subject were known it is hard to see how it could yet be used effectively in the planning of systems which must give coverage at all times of day and season over many years. Therefore the simplified model of triangular hops from an F_2 layer whose median virtual height is known is taken, for purposes of long-term planning, to approximate to the actual conditions over a long period, and is generally used to provide a working solution to the problem. This does not preclude consideration of the effects

* Research Department, British Broadcasting Corporation.

of Sporadic E or normal E layer in cases where their effects become of prime importance.

Test Results.—It was realized from the early days of h.f. broadcasting that it was important to distribute the radiated energy in the vertical plane so that the target area would be efficiently and uniformly illuminated, and as little power as possible wasted. The procedure of the B.B.C. in this matter has been largely based upon the results of tests made with different types of aerial in 1933-35[2], and upon those of later tests made during 1940-43. These indicated that for transmission to the main target areas where multi-hop transmission was

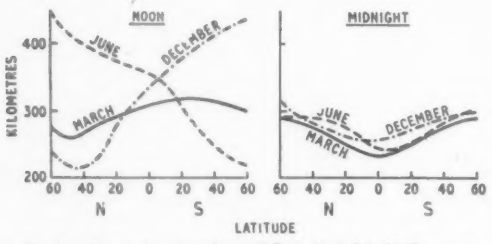


Fig. 2. Approximate values of F_2 virtual height for noon and midnight for March, June and December.

involved the optimum radiation angle was 7° to 8° to the horizontal, and that the vertical radiation pattern should include, between half-field points, a range of angles from 3° to 13° to the horizontal. The standard arrays for long-distance transmissions used by the B.B.C. over the intervening years have been arranged to meet these requirements, where mechanically possible, and the small angle of 7.5° used for the centre of the main lobe. Different types of array have been used by many operating concerns[3] and broadcasting organizations, both in this and other countries but little evidence has come to hand which would suggest that a greater angle is preferable. On the contrary, later tests, and particularly some conducted during the period 1952-54[4], indicate that angles of $7° \pm 2°$, and at some seasons those of $5° \pm 2°$, are the angles at which signals arrive most consistently over certain long-distance paths. We are now in a position, however, to examine the matter from the propagation point of view, using the method mentioned above.

Azimuthal Angles.—The procedure for determining the shape of the radiated pattern in the horizontal plane is quite straightforward. The radiated energy is assumed to follow a great-circle path, so it is necessary to determine the azimuthal angles subtended at the transmitter by the great circles joining the transmitter and the two lateral boundaries of the target area at its widest point. The radiated pattern is then arranged to include these angles, where this is possible, within its half-field points. Though it is recognized that some lateral deviation of the radiated energy can occur, particularly under conditions where there are gradients in the ionization transverse to the direction of the transmission path, tests have shown that these are not, generally speaking, of a systematic kind such as would modify long-term planning.

Vertical Angles.—(*i*) *Virtual Heights.* In order to determine the useful vertical angles it is first of all necessary to know the virtual height, i.e., the points where the apices of the triangular hops will occur, and what we need to do in order to obtain a working solution is to find the *median* virtual height. We therefore examine the measured data on virtual heights for the F_2 layer. Fig. 2 gives the approximate values of F_2 virtual height as obtained from ionospheric measurements, for December, March and June in the latitude range 60° N to 60° S, which covers that part of the earth's surface within which most of the target areas are located. During the night the virtual height is fairly uniform over this part of the earth at all seasons, but during daytime large seasonal variations occur, the values being relatively great in local summer and small in local winter. The median value, for practical purposes, is 320km, and the total range, for by far the greater part of the time over the majority of the target areas, is from 240 to 400km.

(ii) *Propagation Modes.*—Using the median value of 320km a diagram can be constructed which will show, in terms of radiation angle Δ against ground distance D, the various propagation modes which will be present at any distance. This has been done in Fig. 3, the assumption being made that the downcoming angle, measured to the horizontal, is equal to the radiation angle at the transmitter. In this article the modes will be referred to, either by the number of hops appertaining to each, i.e., the 1-hop mode, etc., or, when referring to several at a given distance, by their order in the angular scale, i.e., the first mode, second mode, etc. Thus, at a given distance, the first mode is always that arriving by the least possible number of hops.

It is seen that at any given distance there are present, provided the layer ionization along the

TABLE I

Relative Losses and Field Strength at Receiver Input; Second Mode/First Mode. Angles <1° not Included.

Distance (km x 10_3)	Ground Loss Difference (dB)	Ionospheric Loss Difference (dB)	Receiving Aerial Loss Difference (dB)	Field Strength Difference at Receiver Input (dB)
4	6.4	1.8	−1.8	−6.9
5	6.1	0.8	−3.9	−3.0
6	5.9	1.0	−6.1	−1.3
7	6.1	4.0	−11.3	+1.2
8	6.6	0.0	−4.1	−2.5
9	6.3	2.1	−4.3	−4.1
10	6.2	5.4	−6.4	−5.7
11	6.2	8.3	−13.5	−1.0
12	6.9	2.5	−3.6	−6.3
13	7.8	2.8	−6.4	−4.2
14	6.9	6.7	−8.1	−5.5
15	6.9	7.8	−12.4	−3.3
16	6.7	4.0	−3.4	−7.3
17	6.4	6.9	−4.7	−8.7
18	6.9	9.7	−7.0	−9.6
19	6.5	8.3	−11.0	−3.8
20	7.4	0.8	−4.7	−3.5
Mean	6.6	4.3	−6.6	−4.4
			Focusing Effect	−2.0
				−6.4

path is sufficient to support their propagation, several different modes, and that this is often so in practice has been confirmed both by pulse tests and by downcoming angle measurements. For example at a distance of 10,000km, there could be present a 3-hop mode at 2.8°, a 4-hop mode at 8.4°, a 5-hop mode at 12.8°, and so on. The higher-angle modes, however, are less likely to be present because, with their nearer-vertical incidence at the layer they are more likely to penetrate it, and, of the modes which *are* present, it remains to be seen which one makes the most important contribution to the received field.

For the first three modes shown in Fig. 3 the variation in angle or distance occasioned by variations in the virtual height between 240 and 400km has been shown by means of a shaded area, and the purpose of this will be discussed later.

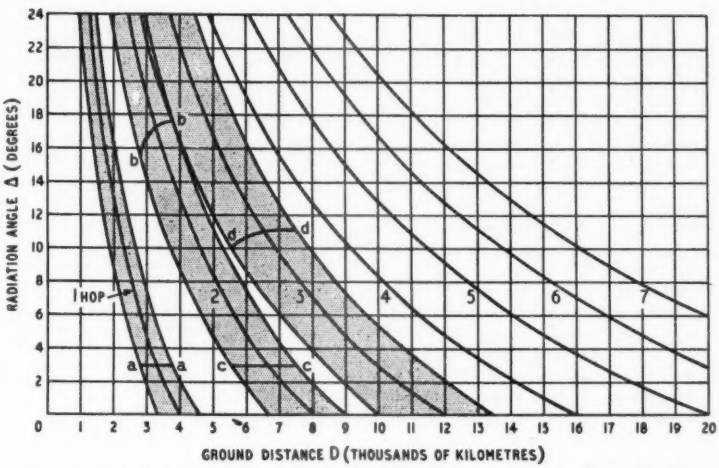


Fig. 3. Mode/distance relationship up to 20,000km for median vertical height of F_2 layer of 320km. Shaded areas indicate effect of variations in F_2 layer height between 240 and 400km.

(iii) *Relative Attenuation of the Modes.*—It is now of interest, in order to see which of the modes gives the highest field strength, to calculate the various losses to which the radiated energy will be subject[5]. In order that the results may be applicable to broadcasting, i.e., to serving a target area of wide dimensions, this should be done for distances ranging from 4,000 to 20,000km, and it is convenient to do it for every 1,000km within that range. It will be sufficient, in order to see whether there is a preferred mode, to obtain relative figures for the first and second modes only, assuming constant radiation over the necessary angular range by the transmitting array, but taking into account the characteristics of the listener's receiving aerial. Since the latter would have little or no pick up at 0° the first mode may be assumed to fade out at 1° to the horizontal. If, in this way, we find that one mode gives a greater receiver input than the other then the radiation angle at which the strongest excitation of this mode will occur should be the optimum radiation angle for the transmitting array, and the total range of transmitting angles required should also become clear.

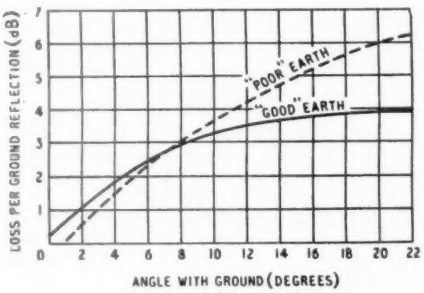


Fig. 4. Ground losses at 15Mc/s.

(*a*) *Free Space Field.*—In the absence of any other losses the radiated energy is subject to the spatial loss, i.e., the loss occurring in the wave front by reason of its spreading out with distance. In the case of transmission between a curved earth and ionosphere over a given ground distance and with a given virtual height, this loss will be slightly greater the higher the order of the mode. However over the range of angles occurring in practice the increase in loss as between the modes is so small that it can, in fact, be ignored.

(*b*) *Ground Loss.*—Energy is lost when the wave undergoes reflection at the ground. This ground loss, for a randomly polarized wave such as emerges from the ionosphere, is a function of the angles of incidence and reflection at the ground, of the nature of the ground, and of the frequency. Within the range of frequencies used for long-distance communication, and with the angles occurring in practice, the loss increases, for types of ground other than sea water, rather sharply with angle, which means that it is greater the higher the order of the mode. Fig. 4 illustrates the case for a frequency midway in the h.f. range. Then, of course, there is the fact that with each increase in the order of the mode an additional ground reflection occurs, i.e., the 3-hop mode has two ground reflections, the 4-hop mode three ground reflections, and so on.

Thus the highest order mode will be most attenuated both by reason of its larger angle with the ground and also by reason of it undergoing a greater number of ground reflections. An examination was made of the ground losses at 15Mc/s for distance intervals of 1,000km between 4,000 and 20,000km, assuming the loss to be midway between that for "good" earth and "poor" earth, and the results are given in the second column of Table 1 in terms of the loss difference between the first and second modes. The loss is greater for the second mode than for the first at all distances, the mean difference being 6.6dB in favour of the first mode. For sea

water the loss difference between the two modes might be as small as 1dB. It must be considered therefore that, on the average, the ground loss for the second mode will be approximately 1 to 7dB greater than that for the first mode.

(*c*) *Ionospheric Absorption Loss.*—The radiated energy is also subject to loss due to ionospheric absorption, which occurs by reason of the dissipation of energy through the electron/molecule collisions which the wave sets up. This occurs principally in the D layer, and since this layer disappears at night, the ionospheric absorption loss over paths in darkness can be considered to be negligible. During daylight, however, this loss must be added to that occurring at the ground. Its magnitude increases with the amount of daylight over the path, with the sunspot number and length of the path, and decreases with increase in frequency. An examination of the ionospheric losses for every 1,000km for 15Mc/s over an all-daylight path during March (for typical high-loss conditions) gave the figures shown in the third column of Table 1. The loss was never less for the second mode than for the first, the mean difference being 4.3dB in favour of the first mode. Thus on the average, the ionospheric loss for the second mode over an area of wide dimensions will be approximately 0dB (night) to 4dB (daylight) greater than that for the first mode.

(*d*) *Ionospheric Focusing.*—Because of the curvature of the ionosphere there is some focusing of the energy such as to favour the most oblique rays. It is difficult to assess the effect of this in practice, but over distances of from 4,000 to 20,000km the mean angle for the first mode would be about 6° and that for the second mode about 11°. The effect of focusing as between these two angles should be to produce a gain of about 2dB in favour of the smaller angle. It would seem reasonable, therefore, to consider that there is a loss of 2dB applicable to the second mode as compared with the first, due to this effect.

(*e*) *Receiving Aerial.*—If the design of the receiving aerial was within the control of the transmitting authority (as is usually the case in the communication services) the next step would probably be to design this so as to have maximum pick up at the angle corresponding to the strongest mode at its fixed distance from the transmitter. The broadcast case is more complex in that the distance is never a fixed one but varies between certain limits, and a variety of aerial types are used, the design of which is outside the control of the broadcast engineer. Dealing with this latter point, it is evident that if the listener's receiving aerial performance is such as to have angular variation in its pick up, then such discrimination will affect the efficacy of the modes in terms of their relative voltage input to the receiver. It is difficult to assess what an *average* broadcast receiving aerial is, but an examination of various types of aerial shows that, in sky-wave reception, they all discriminate markedly against very small angles to the horizontal. In Fig. 5 a curve is given which is the mean value for the five types of aerial listed, of the minimum required field strength against angle, and this may be used for our present investigation. The curve values are given in dB required field strength, so they may be taken directly as relative loss values applicable to the first and second modes. This has been done and in the fourth column of Table 1 are given, for each interval of 1,000km the resultant loss difference between the modes due to the

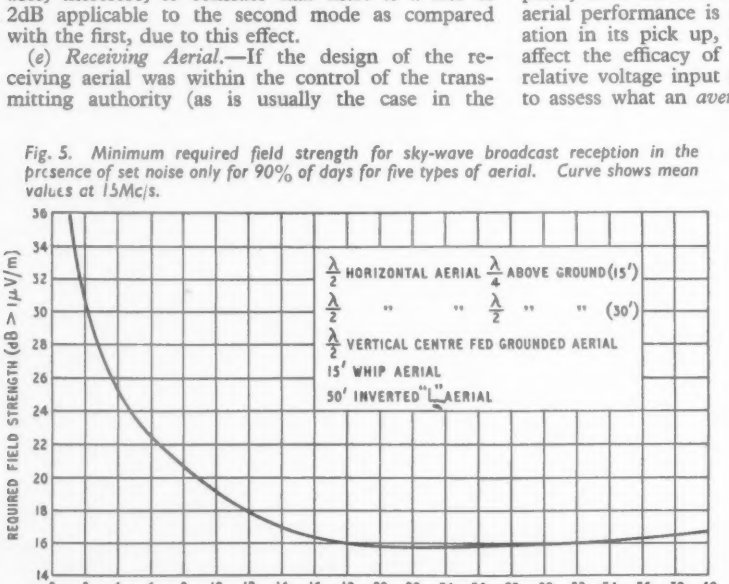
TABLE 2
Loss Differences Applicable to First Mode

Cause	Mean Values (dB)	Cause	Least Values (dB)
Ground Loss (Earth)	7.0	Ground Loss (Mixed Sea and Earth)	4.0
Ionospheric Loss (Day)	4.0	Ionospheric Loss (Night)	0.0
Focusing	2.0	Focusing	2.0
Total	13.0	Total	6.0

TABLE 3

Target Area	Distance Ranges (km)	Mean Angle for First Mode
North and West Africa	2,000— 6,000	10.0°
Central and South Africa	5,000—10,000	7.9°
South Africa only ...	8,000—10,000	6.8°
India and Ceylon ...	5,000— 9,000	7.6°
South-east Asia ...	9,000—14,000	5.8°
Australia and Tasmania	14,000—18,000	4.6°

Fig. 5. Minimum required field strength for sky-wave broadcast reception in the presence of set noise only for 90% of days for five types of aerial. Curve shows mean values at 15Mc/s.


REQUIRED FIELD STRENGTH (dB > 1μV/m)
ANGLE WITH HORIZONTAL (DEGREES)
λ/2 HORIZONTAL AERIAL λ/4 ABOVE GROUND (15′)
λ/2 " " λ/2 " " (30′)
λ/2 VERTICAL CENTRE FED GROUNDED AERIAL
15′ WHIP AERIAL
50′ INVERTED "L" AERIAL

receiving aerial. The loss is always greater for the first mode than for the second (as will be obvious from Fig. 5) and the mean value for all distances is 6.6dB in favour of the second mode.

(*f*) *Receiver Input Field Strength Difference.*—The relative difference for each distance between the resultant field strength at the receiver input of the two modes is given in the last column of Table 1. Except for the value for 7,000km —when the receiving aerial discrimination between first and second modes reaches an exceptionally high value—the first mode is always the stronger, and the mean value in its favour for all distances, when the focusing effect is included, is 6.4dB.

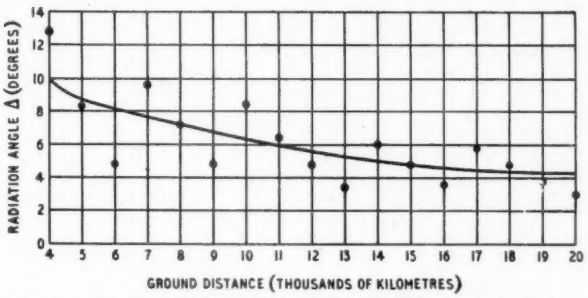


Fig. 6. Variation with distance of radiation angle for strongest mode. Curve gives mean radiation angle for strongest excitation of this mode.

Determination of the Strongest Mode.—It would appear, therefore, that the first mode may be expected to have an average gain of 6dB over any other, and it should be noted, also, that this mode will be the last one to fail due to electron limitation in the ionosphere. However, though this gives us a useful idea of the *average* relative value of the modes, we need to determine the strongest mode for a condition when the relative losses have their smallest value. In this connection it is to be noted that because the first mode is at a relatively low angle, and because the receiving aerial pick up falls so sharply at low angles, there is the possibility that, under the above conditions, the field strength of the first mode may fall below that of the second at a certain low angle. Accordingly, in Table 2 we compare the loss differences applicable to the first mode under these less favourable conditions with the mean loss differences, neglecting the effect of the receiving aerial.

It will be apparent from Fig. 5 that when the angle for the first mode is as low, for example, as 1°, the receiving aerial may discriminate in favour of the second mode by as much as 14dB making it, under these conditions, the strongest by 8dB. In order to select the strongest mode, therefore, we need to establish a low limiting angle at which the receiving aerial discrimination in favour of the second mode will not exceed 6dB. It is evident from Fig. 3 that the angular relationship between the modes varies with distance, but an examination shows that when the first mode is at 3° the second mode has a mean value of 7.8°, at which angle the receiving aerial discriminates in its favour by 6dB. If therefore we take 3° as the low limiting angle for the first mode, we can assume that, even for the least favourable conditions, it should be the strongest mode when averaged over a range of distances. In other words we establish the convention that the strongest mode is that lowest in the angular scale down to a value of 3°, and that at any smaller angle the mode next higher in order becomes the strongest mode, and so on. For the sake of clarity in description we can regard the first mode as fading out at an angle just below 3°, and the next higher mode then becoming the first mode. If then the vertical radiation pattern (v.r.p.) of the transmitting array is such as to excite most strongly the first mode, this should result in the strongest field at any distant point.

One other point should be mentioned here. Though long-distance transmission is generally effected by way of the F_2 layer the radiated energy must, in order for this to happen, be able to penetrate (a) the normal E layer and (b) Sporadic E. For a given ionization in either of these layers it is the energy radiated at the smaller radiation angles which is the less likely to penetrate them, and so reach the target area by way of the F_2 layer. This E-layer " cut off " angle is, however, a variable quantity and at certain times and in some locations may reach a near-vertical angle, in which case it is impossible to effect communication by way of the F_2 layer. These cases can be met in two ways (a) by the use of arrays specially designed for E-layer transmission; (b) by the use of normal arrays with the radiated energy reaching the target area by way of the lower layers, but by means of a greater number of hops than when by way of the F_2 layer. However, because these effects have a limited time duration they are regarded as special cases, and will not be further dealt with here. We should, however, in F_2-layer transmission, avoid paths at very small angles because of these effects.

Optimum Angle for Broadcast Transmission.—In broadcast service the target area often has a distance range across it of several thousands of kilometres, and its distance from the transmitter may also vary. Again, the aerial used often has to be of a " general purpose " kind, capable of serving different areas lying in one, and sometimes in more than one, direction.

Fig. 6 shows, for every 1,000km from 4,000 to 20,000km, the angles, taken from Fig. 3, for the first mode according to the convention we have established. These angles will, of course, start at 4,000km with a relatively large value, decrease to 3°, and then jump to a higher value as the mode corresponding to one more hop becomes the first mode. Though this continually happens with increasing distance the angular range covered decreases as the distance increases. The curve in Fig. 6 shows the mean value of these angles, and thus represents the angle for strongest excitation of the first mode over a distance range. It may be regarded as indicating the optimum angle for transmission to any distance. It has a mean value, for the whole distance range, of approximately 6°, which is not very different from that obtained as the optimum angle from the test transmissions mentioned earlier. It is obvious from Fig. 6, however, that the optimum angle will, in fact, decrease with increasing distance, and will also vary with the dimensions of the target area. Table 3 gives its value for several typical target

areas, the angle being read off from Fig. 6 for the centre of the target area.

In general-purpose, long-distance arrays at present in use, in which the centre of the main lobe is at 7.5°, there is a considerable decrease in power density at 5° and 10°, so that, whilst their v.r.p.s are very suitable for general long-distance purposes, an increase in the incident field strength in certain areas might well be effected by the use of arrays designed for respectively greater or smaller optimum angles, i.e. with the centre of the main lobe nearer the mean angle for the first mode across the particular area. It will also be appreciated that aerial test results for a particular place may indicate an optimum angle higher or lower than the mean value for the whole target area, as indicated by the plotted points in Fig. 6.

Total Angular Range.—Apart from the angle for the centre of the main lobe it is necessary to consider, in connection with the v.r.p., the total range of angles to be included, for example, within the half-field points. We have already considered the minimum angle for the first mode to be 3°, as indicated in Fig. 3 by line *aa*. The corresponding angles for the mode next higher in order for the same distances and range of heights is shown by line *bb*, and it is now evident that if the near boundary of the target area is as close as 3,300km it is necessary for the v.r.p. to cover angles from 3° to 17.6° for there to be no possibility of a break in coverage due to the change from 1-hop to 2-hop transmission, under all likely height conditions. It is extremely difficult, however, to arrange for the v.r.p. of a high-gain array with maximum radiation at approximately 7° to include, within its half-field points, angles as great as 17.6°. If, however, the inner boundary of the service area were at a distance of 4,600km, where the median angle is 10° and the maximum 13°, then the v.r.p. specification is much easier to meet, for at the change-over from 2-hop transmission, which occurs for various heights and distances along the line *cc*, the corresponding angles for 3-hop transmission are those along the line *dd*, the maximum of which is 11°. If, therefore, the inner boundaries of the target areas to be served by general-purpose, long-distance arrays were set at 4,600km, a v.r.p. with maximum radiation at approximately 7° and a total range of 3° to 13°, which is relatively easy to achieve, is adequate. This, again, conforms to what the earlier tests indicated. For distances less than 4,600 km (and there are many target areas with inner boundaries nearer than this) a differently designed array should preferably be used. It is evidently a mistake, however, to attempt to cover places lying relatively near to the transmitting site with a general-purpose, long-distance array, for if this is done there is the danger of a gap in coverage at distances between about 3,000 and 4,000km.

Conclusions.—(1) In the long-term planning of broadcast coverage it is not yet possible to take account of the detailed variations in the trajectories occasioned by short-term ionospheric variations, and it is more feasible to plan on the basis of average conditions, assuming geometrical hops and median virtual heights.

(2) For target areas lying less than 4,600km distant specially designed aerials with a main lobe centred at an angle corresponding to the centre of the target area, and with half-field points at angles corresponding to the inner and outer boundaries, allowing for variations in virtual height, should give satisfactory coverage.

(3) For target areas greater than 4,600km distant best coverage should result when the first mode is most strongly excited, provided this is not at a radiation angle of less than 3°, because this mode may be expected to be, on the average, about 6dB stronger than any other. It also lasts longer than any other mode.

(4) From (3) it is deduced that the v.r.p. of a general-purpose, long-distance array should be such that the centre of the main lobe is at about 7°, and contains, within its half-field points, angles between 3° and 13°.

(5) The v.r.p.s of aerials used to serve specific areas may give better coverage if they are such that the centre of the main lobe is at somewhat greater or smaller angles than in (4), this angle decreasing with increasing distance, and being given by the curve of Fig. 6 for the centre of the target area. The total range of angles which it is necessary to cover will also decrease with increasing distance.

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[2] L. W. Hayes and B. N. McLarty: "The Empire Service Broadcasting Station at Daventry." *Proc. I.E.E.*, 1939, Vol. 14, No. 42, pp. 337-347.

[3] R. J. Hitchcock: "Aerial/Propagation Mismatch." *Wireless World*, December 1957, Vol. 63, No. 12, p. 599.

[4] A. F. Wilkins and F. Kift: "Characteristics of H.F. Signals." *Electronic and Radio Engineer*, September 1957, Vol. 34, pp. 335-342.

[5] The various losses are estimated on the basis of data given in U.S. Signal Corps Radio Propagation Technical Report No. 9.

CLUB NEWS

Bexleyheath.—A film show, including Mullard's "Mirror in the Sky," will be given at the meeting of the North Kent Radio Society at 7.30 on July 10th in the Congregational Hall, Chapel Road, Bexleyheath. Arrangements are being made for the Society to participate in the Borough of Erith's annual show on August Bank Holiday Monday. Sec.—D. W. Wooderson (G3HKX), 39, Woolwich Road, Bexleyheath, Kent.

Bradford.—Members of the Bradford Amateur Radio Society will discuss the question "Which v.f.o. is best?" at their meeting on July 1st at 7.30 at the Headquarters, Cambridge House, 66, Little Horton Lane, Bradford. Sec.—D. M. Pratt (G3KEP), 27, Woodlands Grove, Cottingley, Bingley, Yorks.

Prestatyn.—Two outdoor events have been arranged for the Flintshire Radio Society for July. On the 6th the club's second field day will be held on the Caerwys Mountain, and on the following evening there will be a 160-metre d.f. hunt starting from the Railway Hotel, Prestatyn. Sec.—J. Thornton Lawrence (CW3JGA/T), 9, East Avenue, Bryn Newydd, Prestatyn.

Sidcup.—At the meeting of the Cray Valley Radio Club on July 22nd, C. N. Wridgway (G3GGO) will talk on valve applications. The club meets at the Station Hotel, Sidcup, at 8.0. Sec.—W. E. Sutton (G3FWI), 30, Sherwood Park Avenue, Sidcup, Kent.

Uxbridge.—Thirteen people attended the inaugural meeting of the West Middlesex Tape Recording Club held in the Uxbridge Council Offices on May 13th. Monthly meetings are being planned. Sec.—H. E. Saunders, 20, Nightingale Road, Hampton, Middlesex.

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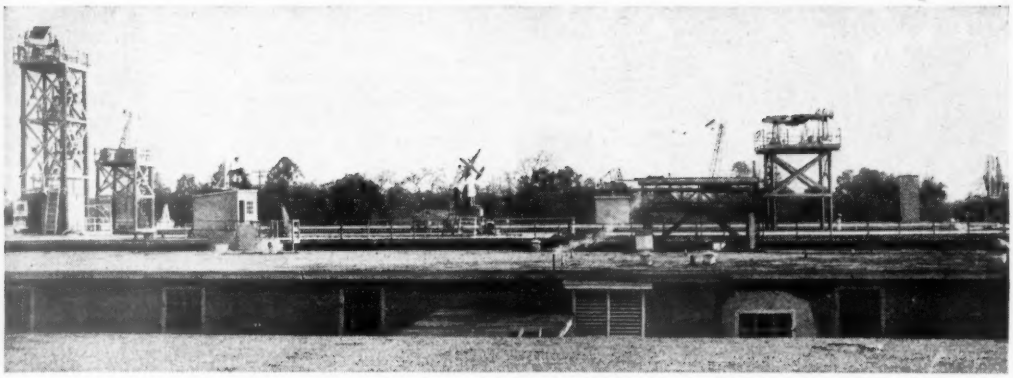


Aerial test range on the roof of the Aircraft Radio Systems Laboratory at Stanford Research Institute in the U.S.

Flush-Mounted Aircraft Aerials

The Role of Scale Models in the Study of Radiation Patterns

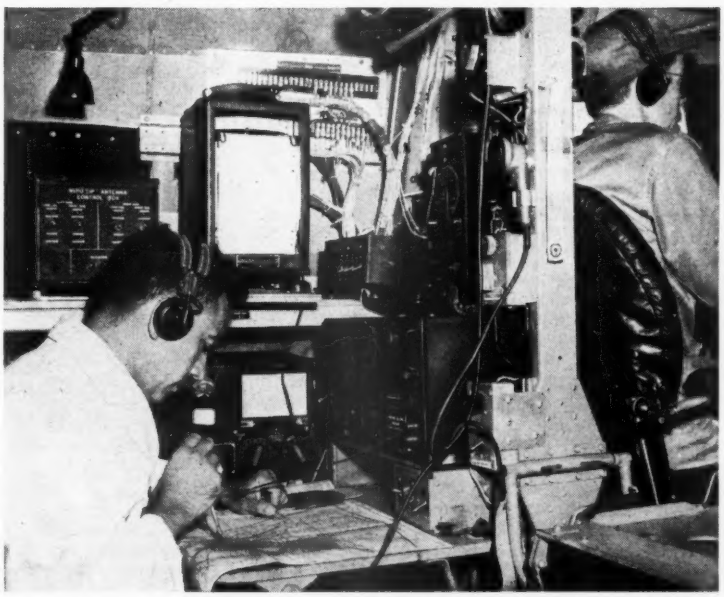
By MICHAEL LORANT

THE complete radio equipment normally carried in an aircraft would consume, if operated simultaneously, electrical power to an amount equivalent to a load of about 7.4 horsepower on the aircraft engines. Several aerials are required for the operation of these equipments. External aerials introduce air resistance which "eats up" horsepower. At 300 miles an hour and at an altitude of 6,000ft, over 90 horsepower is consumed in overcoming the air resistance of these aerials. If they were used on an aircraft flying at 600 miles an hour, over 700 horsepower would be required to overcome their air resistance.

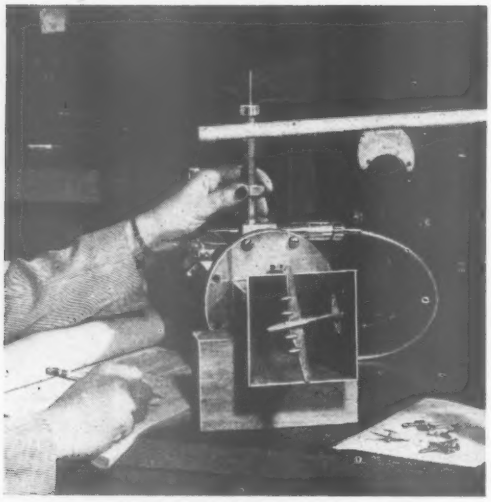
The answer to the problem posed by the poor aerodynamic properties of the aerials lies in "flush mounting,"* the technique in which they are designed in such a way that they can be accommodated wholly within the smooth surface contours of the airframe. The development of this technique requires close co-operation between the aerial and the airframe designers. It requires, as well, the evolution and application of new ideas and new approaches to the mathematical analysis of the behaviour of aerials, and to the experimental determination of their characteristics.

One of the most useful experimental techniques available to the aircraft aerial engineer is the use of scale models. The physical laws governing the behaviour of electro-magnetic waves permit the scaling down of the linear dimensions of the structure under study by a constant factor, provided that

Inside one of the "flying laboratories" used in the study of aircraft aerials.



* Sometimes described as "suppressed aerial" systems.



Resonance phenomena in aircraft structures are studied by the use of microwaves and scale models of aircraft.

the operating wavelength is scaled down by the same factor. This fact permits the use of aircraft models, complete with model aerials and of a size convenient for use in the laboratory, in the determination of aerial characteristics which are equally applicable to the actual aircraft.

Scale models are widely employed in the study of the radiation patterns of aircraft aerials at the Aircraft Radio Systems Laboratory of the Stanford Research Institute in the U.S.A. where advanced studies of aircraft aerial problems are now being undertaken. In this study, a rotatable mount, especially designed and constructed for the purpose, serves to support a model aircraft while it is rotated about the horizontal and vertical axes as the radiated electro-magnetic field is explored. This supporting structure has been designed in such a way that its presence has a negligible effect on the radiated energy. The rotary motion of the model is relayed through a system of electrical repeaters to a recording turntable, on which an electrically-driven recording pen automatically traces out a graphical plot of the radiation pattern.

Similar scale models are being used in the study of the distribution of radio-frequency currents excited on the aircraft skin by the aerial. Since these currents contribute to the radiated energy and to the energy lost to heat because of the electrical resistance of the metal airframe, study of their nature is an important phase of aircraft aerial research.

Extremely small scale models of aircraft (so small that the wingspan of the giant B-29 bomber is reduced to about 4in) are employed in a study of electrical resonance effects in the aircraft structure. A knowledge of these resonance effects is important to the design of flush-mounted aerials for long-distance communications between aircraft, and to the development of such navigational aids as the automatic radio-direction finder.

One significant phase of the work currently under way in the laboratory concerns the use of a single aircraft aerial system for a number of radio equipments. This work is part of an extensive programme of aerial development directed towards a reduction in the structural modifications required to provide flush-mounted aerials for the radio equipment used in existing aircraft. One aspect of this study has led to the development of an automatic aerial matching unit, a device which automatically and continuously "tunes" the flush-mounted aerial to the operating frequency of the radio transmitter with which it is employed. Use of this device ensures the maximum operating efficiency of the aircraft radio system of which it is a part, regardless of changes in the operating frequency or in the aerial characteristics. Such changes might result from the accumulation of ice on the aerial, for instance, which may occur in flight.

This programme also includes the development of other components, primarily filter networks, which serve to allow the various equipments to be operated without interaction. Work on some of these units has led to research, still in progress, on circuits with novel characteristics.

The investigations have contributed extensively to an understanding of such fundamental problems as the diffraction of radio waves by aircraft structures, the excitation of the airframe itself as an aerial for medium-high frequencies, and the relationship between the geometrical properties of wing sections and their behaviour as aerials.

"Radiophonic" Workshop

Part of the new studio and laboratory which the B.B.C. has established at Maida Vale for the evolution and adaptation of new sound effects for creating atmosphere in broadcast plays. Technical resources for manipulating either original or synthesized sounds include tape loop recorders, artificial reverberation and a wide range of filtering and mixing circuits.

Semiconductors Again

By "CATHODE RAY"

Understanding Them from the Energy Point of View

WHEN I first broached the subject of semiconductors (July 1956 issue) my diagrams indicated the relative *positions* of the atoms and electrons in the crystal structure. Even if you didn't see those particular diagrams, Fig. 1 may look familiar, for something of the kind appears in most simple explanations of semiconductor theory. Relative position is one of the few things that can be *directly* represented on paper, and so presents least difficulty at a first approach to a subject.

Lately we have been approaching semiconductors by a different route—*energy*. By now we ought to be quite used to diagrams showing the relative energies rather than positions of the electrons around the atom. There are several reasons for our going into the whole thing again in this way, even with diagrams that come less natural. One reason is that we get a clearer impression of anything by seeing it from more than one viewpoint—in the solid, as it were. Another reason is that in electronics energy is more fundamental than position. Indeed, we have learnt that it is impossible ever to know both energy and position of an electron exactly; and since we do know electron energies fairly precisely their positions are wrapped in obscurity which can be represented in a diagram by nothing clearer than a haze, or at best a graph or equation of probability.

In place of the beginners' position diagram, then, we now have an energy diagram. In single atoms there are a number of possible or "permitted" energy levels, which appear on such a diagram as lines one above the other like the rungs of a ladder. Not more than two electrons in an atom can occupy the same energy level. Apart from disturbances by heat, etc., the electrons settle down into the lowest possible levels, all those above being empty. The levels occur in groups, and except for the inert gases (which have all their groups just filled) there are one or more electrons above the highest filled group, called valency electrons. These are much more important than the others, because they bear almost the whole responsibility for external relations, as in chemical combination, solidification, etc. The lower-energy electrons are therefore often lumped together with the nucleus as "the atom" while we concentrate attention on the valency electrons. Fig. 2, for example, ignores all except the valency electrons. In a crystalline solid, to which Fig. 2 refers, the interaction between the closely spaced atoms causes their single equal energy levels to spread out into innumerable closely-spaced levels which can be regarded as a continuous band. The highest levels spread out most, and often two bands overlap, especially in metals, which have no gap between the valency band and the next higher band. These therefore have plenty of scope for the electrons to accept the small amounts of energy available from the electric field set up by an e.m.f., and the material is a good conductor. A sizeable gap—say, several eV

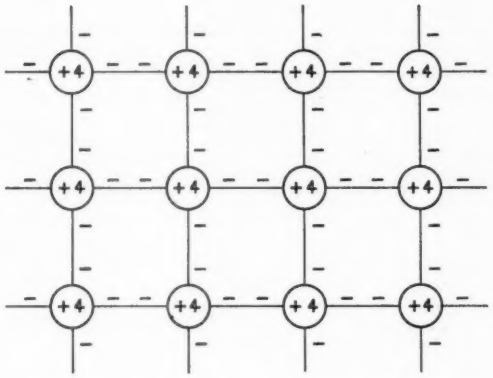


Fig. 1. This kind of diagram is intended to show, albeit somewhat crudely, the relative positions of the parts in solid structure.

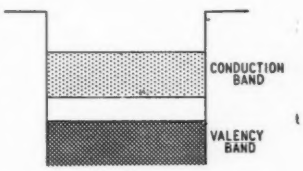


Fig. 2. Simple energy diagram for a solid, ignoring all except the band of energy levels filled by the valency electrons, and the next higher band, which is empty.

(electron-volts)—above a band full of electrons prevents them from accepting such energy, and the material is an insulator. But if the gap is not much more than 1eV an appreciable number of electrons get enough energy from heat (or light) to cross the gap and thereby become available for conduction.

Of the elements whose atoms have four valency electrons each, carbon in the form of diamond has such a wide gap that even at quite high temperatures hardly any electrons can cross, so it is an insulator. Silicon—the next in order of atomic number—has a gap of about 1.1eV, which can be crossed by very few electrons at room temperature but by appreciable numbers when hot. Germanium has a gap of about 0.7eV, which means that it conducts slightly even at room temperature, and quite a lot at 100°C. Like silicon, it is classed as a semiconductor. Tin and lead have no gap at all, so they are good conductors at any temperature.

As the title says, we are concentrating now on semiconductors. I mentioned last month that the sort of semi-conduction just described is called *intrinsic*, because it is a property of the material itself. For most practical purposes it is wholly unwanted. The sort of conduction we actually use, in rectifiers and transistors, is due to impurities. The word "impurity" usually suggests something undesirable, but in this case it is an essential.

Impurity conduction is explained with position

diagrams by saying that when an atom of some element with five valency electrons (such as arsenic) usurps a place in the crystal lattice structure it has one spare electron, which is free to take part in an electric current. So such an atom is called a *donor*. An atom with three valency electrons (such as indium) has one electron short, leaving a hole into which an electron from elsewhere can move, again giving rise to a current. This kind of impurity is called an *acceptor*.

While all this agrees pretty well with the behaviour of actual materials and makes a nice easy story for a first approach, it doesn't fit very well into our more enlightened (we hope!) picture in which *all* the valency electrons are in continuous rapid circulation. In this picture, the few electrons that are available for taking part in currents—the conduction electrons —cannot be distinguished by their positions from the many that aren't. That is where energy diagrams come in. In Fig. 2, representing a perfectly pure semiconductor, the valency electrons, which are extremely mobile as regards position, fill the valency band so completely that they are altogether immobile as regards energy. They can do no more than exchange (energy) places, causing only small local currents that cancel one another out. The only ones available for through traffic are the few that get enough energy from heat, etc., to rise into the empty or conduction band.

Last month I advised you not to forget all about Fermi and his curve and you may be wondering when he is going to reappear. The answer is, now. The reason is that the Fermi curve is a great help in understanding semiconductors, and especially junctions between different kinds.

A Fermi curve is plotted from an equation arrived at by theory and confirmed pretty well in practice:

$$F = \frac{1}{e^{(E-E_F)/kT} + 1} \quad \text{or} \quad \frac{1}{10^{\,0.4343(E-E_F)/kT} + 1}$$

Here E, energy level, is the variable, and F is the proportion of permitted electron energy states at that level which are occupied by electrons.* E_F is a constant energy level for any particular material, and is called the Fermi level. At that level ($E = E_F$) the exponent is zero, and any number to the power zero is 1, so $F = \frac{1}{2}$. In other words, the Fermi level is the boundary between energy states which are more than half full and those that are more than half empty. T is the absolute temperature, which under living conditions is usually about 290°K (17°C); and k is Boltzmann's constant, 8.6×10^{-5} eV per degree, so at 290°K the value of kT is 0.025eV. When E is 0.1eV above E_F, F works out at 1/55, which means that nearly 2% of available energy states are filled. At 10 times that height above the Fermi level, F (thanks to the exponential relationship) is only about 0.00000000000000005%! At *below* E_F, the figures are the same for the proportion of places *not* filled.

Fig. 3 is a typical Fermi curve. A look at the equation shows that at higher temperatures all the values of $E-E_F$ (at a given F) go up in proportion, so that the curve slopes more steeply. This expresses in an exact way the fact that heat raises more electrons to the higher energy levels. When the temperature is reduced to 0°K the curve flattens out until it coincides with the Fermi level E_F, which means that all possible levels up to that are completely filled with electrons, and all those above are completely empty.

In a metal, all energy levels in the range covered by the important part of the Fermi curve are " available " or " possible "—there is no gap between the basic valency levels and those into which electrons can be lifted by heat, etc.—so if the energy levels in a band were all equally spaced the Fermi curve would also represent to scale the actual distribution of valency electrons at the temperature for which the curve was plotted. The whole area below it would represent the total number of electrons in the crystal. As it happens, the levels are not equally spaced, but over the range concerned this doesn't make any very vital difference and the Fermi curve does roughly show the energy distribution of valency electrons in metals. In particular, the portion of area above E_F represents fairly well the number of electrons displaced, and the equal area between E_F and the right-hand half of the curve represents the number of vacancies thus created. The same thing is shown rather crudely but more picturesquely in Fig. 4.

But what happens when there is a gap, as in semiconductors? By definition, a gap is an energy band within which there can be no electrons, so the Fermi curve cannot then represent actual electrons all the way up. But since any electrons displaced inevitably create an equal number of holes, it is clear that the only place for the Fermi level is half-way up the gap, as in Fig. 5. At any other position, the areas representing free electrons and holes would be unequal.

To make the electron displacements big enough to see in this diagram, the Fermi curve has been drawn to represent either an unusually narrow gap or high temperature. In other words, it represents a semiconductor with unusually high conductivity. In practice, the proportion displaced would be far smaller, especially in silicon. Even in germanium only one electron in about five million can cross its 0.7eV gap at room temperature. As we saw last time, the Fermi relationship can be used to calculate the

(*Continued on page 341*)

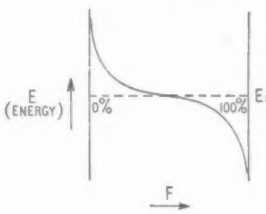


Fig. 3. Typical Fermi curve, showing the proportion of energy states filled (F) at any energy level (E). E_F, the Fermi level, is the half-filled level (except at 0°K, when it is the boundary between completely filled and empty).

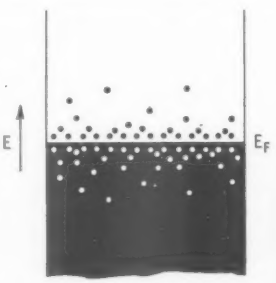


Fig. 4. Pictorial and less exact representation of what the Fermi curve conveys—the distribution of electrons (black) and the vacancies created below the Fermi level by those raised above it by heat.

*You may object that there are never more than two places for electrons at any one energy level. But the Fermi curve refers in effect to a very narrow band centred on level E. Even a band no thicker than a printed line on the graph can include vast numbers of electrons.

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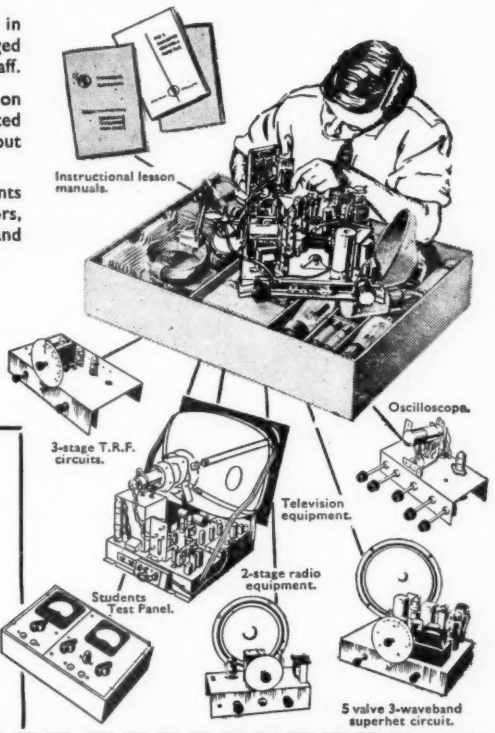

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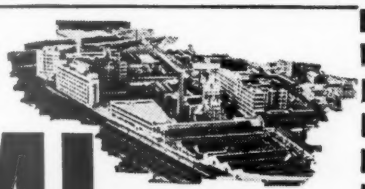

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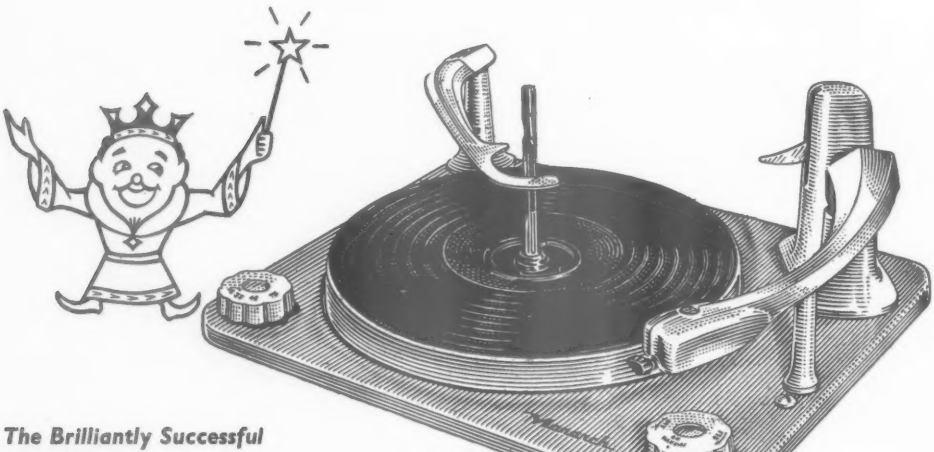

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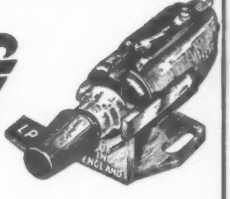

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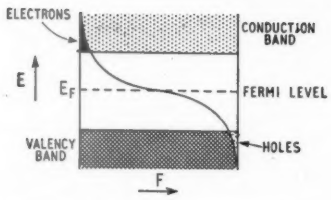


Fig. 5. How the Fermi curve is placed in the energy diagram of a pure semi-conductor. The intrinsic conduction is due to the mobility of the electrons in the conduction band and the holes in the valency band. The higher the temperature, the steeper the Fermi curve, indicating more free electrons and holes, so greater conductivity.

number of electrons raised to the conduction band at any temperature. Some further calculation gives the intrinsic conductivity. As one would expect from the Fermi equation, it increases (i.e., resistance falls) very rapidly with temperature.

Now we come to the interesting part—impurity conduction. Either of the two kinds of useful impurity (donor or acceptor) has its own little valency band. It is higher than that for germanium or silicon; comes in the gap, in fact. If of the donor type, its band is only about 0.01eV below the top of the gap, as shown in Fig. 6.

Now if we assume that the Fermi curve remains in the middle of the gap as in Fig. 5, and calculate the value of F at the bottom of the conduction band at 290°K we find it is less than one-millionth. Only 0.01eV lower it is little different, which means that less than one in a million of the impurity atoms have their valency electrons present. Where have they gone? Across the narrow gap into the conduction band.

Even if there is only about one part in a million of impurity, the fact that practically *all* its valency electrons have been lifted into the conduction band enables them to outnumber the very few electrons that succeed in crossing the main gap. So even when the amount of impurity would seem by ordinary standards to be negligible, impurity conductivity can swamp intrinsic conductivity.

It is not only by outnumbering the original intrinsic conduction electrons that impurity does this. To represent the increased number of electrons in the conduction band, the Fermi curve has to be raised so that the Fermi level is above the half-way position (Fig. 7). This inevitably indicates a reduced number of holes in the valency band, which means that the intrinsic conductivity is less than it was before the impurity was added. If we went into it in more detail we would find that the number of electrons in the conduction band *multiplied* by the number of holes in the valency band was constant.

Obviously the greater the amount of impurity to supply the conduction band with electrons, the higher the Fermi level must be if the area within that band and below the Fermi curve is to represent the number of electrons. It is true that the new position of the curve indicates more electrons retained in the impurity band, but even if it went up from one in a million to ten in a million it would still be negligible.

What happens when we vary the temperature? Raising it steepens the slope of the curve and increases the number of electrons raised from the vast resources

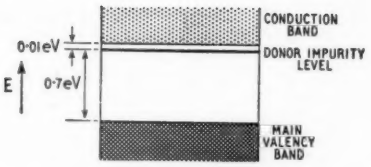


Fig. 6. A donor impurity level is so near the conduction band that at ordinary temperature almost all its valency electrons are found.

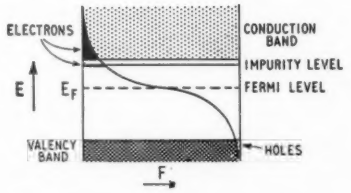


Fig. 7. The increased number of conduction electrons resulting from impurity means that the Fermi curve is higher up the gap, so the number of "intrinsic" holes decreases.

of the main valency band. The impurity band, on the other hand, has already yielded practically all its electrons, so is in no state to compete. Beyond the point where main electrons outnumber the impurity electrons the conductivity increases (resistivity falls) very steeply, and the Fermi level approaches the centre of the gap. Clearly, the temperature at which this "roll-off" takes place is higher the greater the amount of impurity or the lower the intrinsic conductivity. So we get curves something like Fig. 8, in which the slope on the right represents the effect of intrinsic conduction. If these curves refer to germanium, a corresponding set for silicon would have this slope farther to the right.

Lowering the temperature has little effect if one starts from a point where most of the conduction is by impurity electrons. There is a slight rise in resistance due to elimination of the remaining intrinsic conduction. When this has happened, the Fermi level is somewhere near the impurity level. Then there is a slow fall for the same reason as in conductors. It is only when the temperature is nearly down to zero that the impurity electrons have much difficulty in crossing the 0.01eV gap; then, with the Fermi curve almost horizontal and above the impurity level, the resistance rises as shown by the turn-up at the extreme left of Fig. 8.

The useful working conditions are within the flat range. It is because room temperature is near the right-hand end of this range for germanium that devices made of it have such limited temperature ratings compared with silicon.

So much for semiconductor with donor impurity, known as *n* type because the current carriers are electrons, which are negative charges. There is hardly need to go through the story of semiconductors with acceptor impurity in such detail, because it is the same except for being upside down. The impurity band is only about 0.01eV above the main valency band, so contributes a completely negligible number of electrons to the conduction band, but electrons in the main valency band cross the narrow gap into the impurity band almost to the complete

extent of the very limited accommodation there. Practically all the impurity atoms are thereby converted into fixed negative ions. This removal of some of the top electrons from the valency band leaves room for others to move up, just as removals to Head Office leave room for promotions within a branch. Such movements of electrons, when there is an applied e.m.f., are an electric current. So this sort of impurity too enables the material to conduct. The number of vacancies created in the valency band is limited by the number of impurity atoms, not by the vastly greater number of electrons in the valency band that have enough energy to jump the narrow gap.

These vacancies are commonly known as holes. Many quite learned gentlemen of the old school seem to find them mystifying. I don't know why. It should be as easy to see that the movement of a hole in one direction is really a lot of shorter movements of electrons in the opposite direction as it is to see that movement of the bubble in one direction along a spirit level is really a lot of shorter movements of drops of spirit in the opposite direction. It is just more convenient to refer to what happens as the movement of a bubble or a hole than the much more complicated movements of electrons or spirit. Since movement of electrons in one direction is equivalent to movement of positive charges in the opposite direction, holes are equivalent to positive charges, and material with acceptor impurity is called *p* type.

The only practical difference, apart from polarity, between *n*-type and *p*-type conduction is that—as one might expect—a hole takes rather longer to move past all the electrons concerned than an electron takes to move an equal distance. In official terms, its mobility is less.

The equivalent *p* diagram to the *n*-type Fig. 7 is Fig. 9, and the effects of varying temperature and amount of impurity are similar.

Now we come to the crucial matter of what happens when *p* and *n* materials are brought into intimate contact. The " position " story tells how electrons in the *n* region find themselves with no barrier between them and an almost electronless *p* region, so they start spreading across into it. Similarly the holes in the *p* region spread into the *n* region. Both of these movements are equivalent to a conventional positive current from *p* to *n*, and very quickly the *n* region becomes positively charged relative to *p*. The electrons and holes thus automatically establish a barrier against their own further trespassing. A balance is established when this potential barrier is enough to suppress any net inter-region movements.

Let us see how this compares with putting the corresponding energy diagrams together—Figs. 7 and 9. If we do so with the conduction and valency bands in line all the way across we see that the electrons are unequally distributed, being more on the *n* side than the *p*. Similarly holes are more numerous on the *p* side. If we alter the alignment until electron and hole density is the same at any level, as in Fig. 10, we find that the Fermi level is necessarily the same right through, and it is the energy levels or potentials of the material that have to change on going from one region to the other.

This represents a condition of balance, in which most of the electrons remain on the *n* side because they have insufficient energy to climb the step that leads to the *p* region. The few (intrinsic) electrons on the *p* side of the conduction band tend to drop down this step into the *n* side, but are exactly balanced by the small fraction of the many electrons on the *n* side that have enough energy to bring them to the same level. One can perhaps picture the thing better by replacing the Fermi curves by the Fig. 4 type of picture, with lead-shot electrons kept in a stage of agitation which gives them a Fermi distribution. Similarly holes, like bubbles, tend to float up to the top of the valency band, but again there is a balance with those few that are created at relatively low levels on the *p* side.

There are more scientific ways of examining the *p-n* problem, but they too lead to the conclusion that the whole combination has a common Fermi level. They also confirm that our lead-shot-and-bubble mechanical model is basically sound The level changes less abruptly than suggested in Fig 10, however; there is actually what is called a transition zone, but it is usually only about a thousandth of a millimetre thick.

One of the most important things is the height of the step in volts—the difference of potential at the junction. Our E scale is in electron-volts, and since the particles concerned on the *n* side are electrons the scale also measures p.d. in volts. But because electrons are negative charges, it measures negative volts. So the fact that the *n* side is lower than the *p* side means that it has a *higher* positive

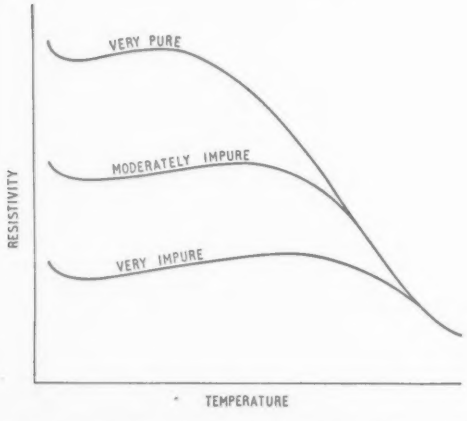


Fig. 8. The peculiar shapes of these resistivity/temperature curves for a semi-conductor can be predicted from Fermi theory.

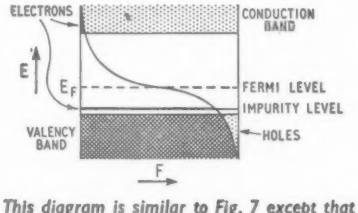


Fig. 9. This diagram is similar to Fig. 7 except that the impurity is p type, bringing the Fermi level below the middle of the gap.

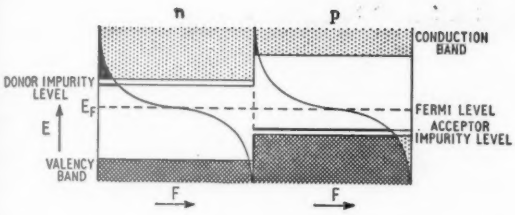


Fig. 10. When n- and p-type materials are in close contact, electron and hole densities at any level must be the same throughout. This necessitates the Fermi level being the same throughout and creates a potential step at the junction.

potential, which agrees with what the particle-diffusion story told us.

If you have been following everything you should be able to predict broadly what happens if the temperature is raised or lowered or if the proportion of impurity is increased or decreased. For example, assuming that the material is germanium at ordinary temperature, so that conduction is predominantly by impurity carriers, the dark area representing free electrons on the *n* side of Fig. 10 must be considerably larger than that on the *p* side. For this to be so the separate Fermi levels must be considerably displaced above and below the centre of the gap. The potential step is equal to the sum of these displacements (usually of the order of 0.3V). If the material is heated, the intrinsic conduction is increased, so the electron area on the *p* side must be greater, the Fermi level displacement less, and the potential step smaller. This also happens if the amount of impurity is less, since there are fewer electrons to be presented by the dark area on the *n* side. If two regions of the same type were in contact, their Fermi levels would be the same distance up the same gap, so there would be no potential step.

Books and articles on this subject carefully avoid explaining how it is that the difference of potential between the terminals of a *p-n* rectifier (or either pair of adjacent terminals of a transistor) is not detectable by even a very high-resistance valve voltmeter. Last September I rashly and rather unthinkingly ventured a diagram (Fig. 7 on p. 434) that purported to supply such an explanation. It drew from Mr. A. Richardson of Newcastle the observation that a homogeneous, electrically isotropic, conducting piece of material at uniform temperature, subject to even a small potential gradient without a current, was such an unusual state of affairs as to be worth an article to itself. He hoped I would return to the subject. This I now do by withdrawing that explanation in favour of the answer that the junctions elsewhere in the circuit (notably the metal-to-semiconductor junctions) introduce counteracting potential steps.

Having (I hope) disposed of that difficulty we can now come to what happens when an e.m.f. is applied to the *p-n* terminals from some external source. Because it alters the relative pontentials of the two regions, it forces their Fermi levels apart by an amount equal to its own voltage. Suppose first the external source is positive to *n*. That is represented on the diagram by a relative lowering of the *n* side, as in Fig. 11. The result is that the

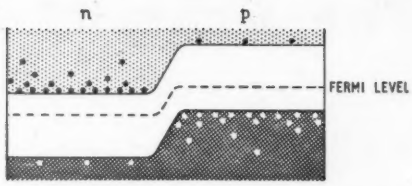


Fig. 11. Forcing the Fermi levels apart by an externally applied voltage either increases the step, restricting the current flow to intrinsic carriers only (as here), or reduces it, increasing the flow of impurity carriers.

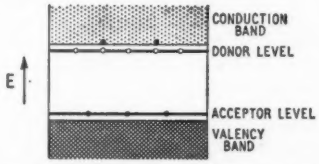


Fig. 12. Diagram showing "compensation," whereby the effective impurity when both are present is equal to the difference between the two.

impurity electrons on the *n* side are faced with a higher step, so stand even less chance than before of surmounting it. The intrinsic electrons on the *p* side easily fall down to the *n* side. Similarly for holes from *n* to *p*. There is therefore a current from *n* to *p*, which is the direction of the applied e.m.f. But because these carriers are few in number at ordinary temperature, this current will be small. For the same reason, it cannot be increased by applying a greater voltage (short of breakdown). However, it will increase rapidly with temperature.

If the applied e.m.f. is of the opposite polarity, the height of the step will be reduced. This obviously will make the impurity electrons spill over from the *n* to the *p* side. Since the original height of the step was only a fraction of a volt, a "forward" e.m.f. of comparable amount is enough to release very considerable quantities of electrons from *n* to *p*, and similarly holes from *p* to *n*. So it is quite easy to see why a *p-n* junction is a rectifier.

Finally, just one more important point. In real life it is more than likely that there would be some of both kinds of impurity in the same material, and one might expect this to complicate the situation quite a lot. But it's really quite simple. Suppose for example there are five donor atoms for every three acceptor atoms, as shown diagrammatically in Fig. 12. Neglect intrinsic conduction. One might guess that three electrons would jump up from the valency band to the acceptor atoms, creating holes, and the five electrons in the donor band would jump up into the conduction band. In other words, the two impurity conductions would *add*. But the donor electrons find it much easier to drop their electrons to the acceptor atoms, putting them out of action as acceptors from the valency band, and only two donor electrons are left for the conduction band. In general, then, the two impurity conductions *subtract*. The result is that semiconductor material can be "purified" by adding an equal quantity of the opposite kind of impurity to that already present. There are practical limits to this dodge, but it is very useful for converting *p* to *n* and vice versa.

The Schmitt Multivibrator

Reliable Design Procedure and Uses of the Circuit

By G. L. SWAFFIELD

OF the several types of multivibrator circuit in use today, one remains in relative obscurity, possibly due to its comparative complexity of design.

In its simplest form this multivibrator circuit comprises a free-running cathode-coupled pair of triodes and is very useful both as a master pulse generator and for providing a repetitive sawtooth waveform.

At one anode a positive-going pulse is generated, being coincident with the flyback of the sawtooth waveform, and this pulse, developed across a " free " anode load, may be used among other purposes for suppressing the flyback of the sawtooth if the last-mentioned is utilized for scan generation.

A high and variable mark-space ratio of the pulse waveform is obtainable without necessarily altering the pulse width, and the circuit p.r.f. is readily synchronized to either a positive- or negative-going external pulse source.

A simplified design procedure is presented below

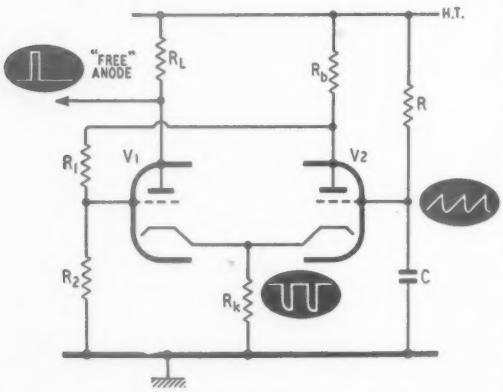


Fig. 1. Basic Schmitt multivibrator circuit.

in which circuit values are obtained by successively substituting the appropriate specification figures in a series of formulæ. Within reason, this process enables the specified a.c. waveforms to be generated at predetermined d.c. levels.

The simple circuit arrangement is shown in Fig. 1, where it is seen to consist basically of the well-known Schmitt trigger circuit.[1] In fact regeneration from stage 1 to stage 2 is due to the high degree of " backlash " or overcoupling between these stages and in this respect it is identical to the conventional Schmitt trigger circuit. Relaxation, on the other hand, is due to the network CR in the grid circuit of V_2.

[1] " A Thermionic Trigger," by O. H. Schmitt. *Journal of Scientific Instruments*, 1938, 15.

Before the h.t. voltage is applied to the circuit, capacitor C is uncharged and the grid of V_2 is at earth potential. As soon as the h.t. voltage is applied, however, V_1 grid is raised to a positive potential determined by the chain of resistors R_b, R_1 and R_2. Because V_2 grid is instantaneously at earth potential, V_2 is biased off by the large grid-to-cathode voltage thus produced. Capacitor C will therefore commence to charge through resistor R toward h.t. and the potential at V_2 grid rises according to the exponential curve in Fig. 2.

V_2 grid will thereby rise to within a grid base of the cathode potential, and as soon as V_2 begins to conduct the anode current flowing through the anode load R_b lowers the potential of V_1 grid via the coupling R_1 and R_2. The gain of the circuit in this direction is designed to be great enough to ensure that V_1 is biased off by this drop. This high gain requires a high value of anode resistor R_b and as a result the anode current in V_2 is much less than that in V_1. Consequently the cathode potential is much reduced and V_2 grid is now highly positive with respect to the cathode. Capacitor C then discharges through the diode formed by the grid and cathode of V_2, the time of discharge being determined by the value of C and the effective resistance of the diode and cathode resistor.

As the potential of V_2 grid, and hence that of the cathode, falls during discharge, the bias on V_1 grid decreases, reaching a value at which V_1 can once again draw current.

The cycle of events can now be repeated and a free-running multivibrator action results. The time relationship of the appropriate waveforms is shown in Fig. 3.

The frequency of oscillation depends mainly on the values of C, R and R_k and the h.t. voltage, and can be synchronized to an external source in such applications as line or frame scan generators. Positive synchronizing pulses are fed to the grid of V_2, and negative pulses to either V_1 grid or the cathode.

The diagram of Fig. 3 also indicates the symbols used to denote the positive and negative peaks of the waveforms generated. For example the cathode waveform has a positive peak and hence d.c. level of V_k'' and a negative peak and d.c. level of V_k'. These symbols are used in the formulæ that follow.

In each and every instance the suffix 1 refers to potentials associated with V_1 in all diagrams, and suffix 2 to those relating to V_2.

A procedure which permits the design of a.c. waveforms at predetermined d.c. levels can be complicated by the interdependence of the values of R_b, R_1 and R_2. These values in turn determine the operating conditions of the valves.

If, however, the specification for a multivibrator performance is interpreted first in terms of valve d.c. operating conditions, then appropriate resistance

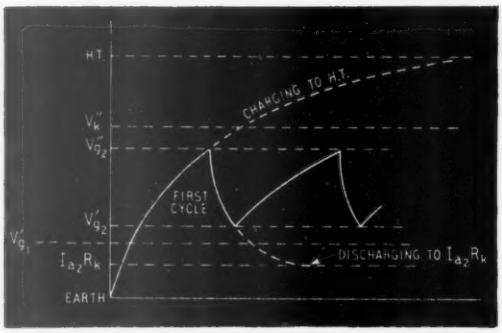


Fig. 2. Sawtooth generation and associated d.c. levels.

values can be solved easily from a series of formulæ.

Typically a specification for the circuit performance may define one or all of the following outputs.

1. Rise time (t_r) of the pulse at the free anode (anode 1) between 10% and 90% full value.
2. Amplitude (V_o) and d.c. level (V_{a1}) of the pulse at the free anode, and pulse width (t_d). (See 5 below.)
3. Amplitude (A) and peak positive d.c. level (V_{g2}'') of sawtooth at grid 2.
4. Time of sawtooth scan (t_c).
5. Time of flyback of sawtooth (t_d). This determines the free anode pulse duration also.

Coming now to the actual design procedure of the circuit, the steps are as follows:—

1. Determine V_1 anode load R_L from the well-known formula:—

$$t_r = 2.2C_sR_L$$

where C_s is the value of stray capacitance associated with the free anode circuit.

$$\text{Hence } R_L\ (\text{k}\Omega) = \frac{t_r\ (\text{m}\mu\text{sec})}{2.2C_s\ (\text{pF})}$$

2. Determine V_1 anode current I_{a1} to flow through R_L to give the required output amplitude V_o:—

$$I_{a1}\ (\text{mA}) = \frac{V_o}{R_L\ (\text{k}\Omega)}$$

The specified d.c. level V_{a1} is obviously the difference between the h.t. potential and the amplitude of the output pulse V_o. To obtain the correct d.c. level it may therefore be necessary to resort to dropping and decoupling components in the anode circuit.

3. The peak positive d.c. level V_{g2}'' corresponds within a grid base to V_k'', which in turn equals $I_{a1}R_k$. Allowing for a grid base, estimated from valve curves, calculate V_k'', and hence R_k from:—

$$R_k\ (\text{k}\Omega) = \frac{V_k''}{I_{a1}\ (\text{mA})}$$

4. For the known h.t. value, determine the modified V_1 anode current and appropriate grid bias V_{gk1} (resulting from the use of nearest available values of R_L and R_k to those calculated) necessary to develop the specified d.c. level at either V_1 anode or V_2 grid, whichever is the more important. The grid bias V_{gk1}, added to V_k'', gives the positive peak value of V_1 grid voltage V_{g1}''

i.e. $V_{g1}'' = V_k'' + V_{gk1}$

If no d.c. level is specified either for the sawtooth waveform at V_2 grid or for the cathode potential V_k'', the last-mentioned can only be allocated by intelligent use of the valve characteristic curves. Choose a level which is consistent with valve dissipation requirements while at the same time keeping V_1 out of grid current. As a very rough guide, a minimum level of 30% of the h.t. voltage can be used if power dissipation considerations allow it.

It will then be necessary to add $V_{c_{02}}$, the grid base of V_2, to V_k'' selected by this means, to determine V_{g2}''. (Note that $V_{c_{02}}$ itself is dependent on V_2 anode-cathode voltage and hence on V_k''.)

Thus $V_{g2}'' = V_k'' + V_{c_{02}}$

5. From V_{g2}'', the positive peak of the sawtooth, subtract A, the required amplitude of sawtooth, to obtain V_{g2}', the negative sawtooth peak:—

$V_{g2}' = V_{g2}'' - A$

Since V_2 is drawing grid current at this level, V_{g2}' is slightly positive with respect to the lower cathode potential V_k'. V_k' will therefore be approximately a volt less than V_{g2}'.

Thus $V_k' \doteqdot V_{g2}' - 1$

6. Knowing R_k, the cathode current I_k can now be calculated:—

$$I_k = \frac{V_k'}{R_k}$$

Note that I_k is due to the sum of grid and anode currents of V_2:—

i.e., $I_k = I_{g2} + I_{a2}$

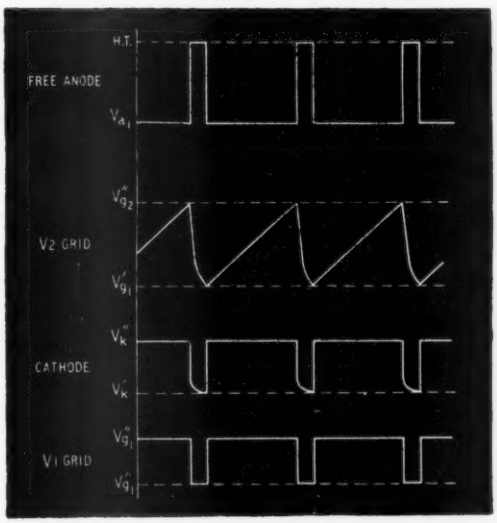
7. Valve curves giving both grid and anode characteristics must now be used to determine the grid and anode currents flowing at the end of the discharge cycle.

Typical curves for the 6J6 or ECC91 are given in Fig. 4.

A trial and error process is involved here, since both grid and anode currents must be selected from separate curves, each corresponding to the grid-cathode potential determined earlier and at the same anode-cathode potential. It may be found at this stage that the positive grid bias estimated in stage 5 is too great, in which case a smaller value must be assumed.

In any event from this process an anode-cathode

Fig. 3. Time relation of generated waveforms.



voltage V_{ak2} will result for V_2 when the last-mentioned conducts, generally lying between 5 and 30 volts.

Adding this value to V_k' will give the conducting anode potential V_{a2} of V_2:—

$$V_{a2} = V_k' + V_{ak2}$$

8. Finally calculate the negative level at V_1 grid, V_{g1}'. To do this use the valve characteristics to estimate the grid base V_{c01} of V_1 for the known h.t. potential and cathode potential V_k'.

Hence $V_{g1}' = V_k' + V_{c01}$

This completes that part of the design procedure involving static valve parameters. The remainder consists first of solving values for the resistance chain R_b, R_1 and R_2 by substituting the appropriate d.c. levels obtained above in the formulæ that follow, and secondly, calculating the value of C and R to produce the specified scan and flyback times.

9. Solve R_b from

$$R_b = \frac{\text{h.t.}}{I_{a2}}\left[\frac{V_{g1}'' - V_{g1}'}{V_{g1}''}\right]$$

10. Solve R_2 from

$$R_2 = \frac{R_b}{\text{h.t.}/V_{g1}'' - V_{a2}/V_{g1}'}$$

11. Solve R_1 from

$$R_1 = R_2(V_{a2}/V_{g1}' - 1)$$

12. While capacitor C discharges via the grid-cathode diode of V_2 into cathode resistor R_k, I_{a2} is approximately constant if R_b is high. C therefore discharges into a grid-cathode impedance in series with R_k across which a potential difference of $I_{a2}.R_k$ exists.

Capacitor C will thus discharge from V_{g2}'' towards $I_{a2}\,R_k$, but will in fact be caught at a level V_{g2}'. If the charging resistor R is high the current drain through this component is negligible and the discharge law is exponential. Fig. 5 gives superimposed graphs of the normal capacitor charge and discharge curves with the time constant ratio $\frac{t}{CR}$ plotted against $\left(1 - \epsilon^{-\frac{t}{CR}}\right)$ and $\epsilon^{-\frac{t}{CR}}$ respectively.

Fig. 4. Grid and anode characteristics of the 6J6 or ECC91 valve.

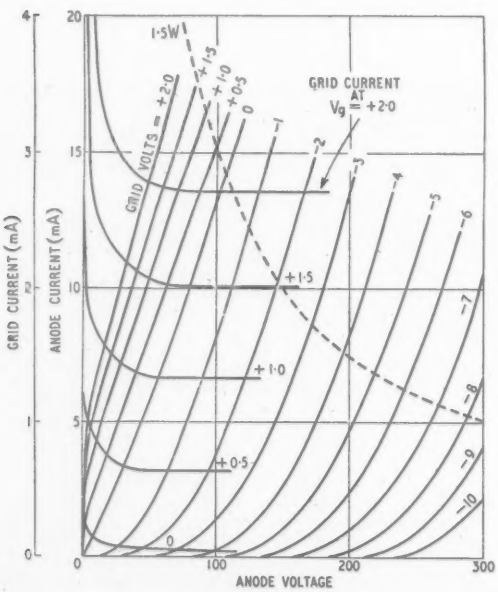
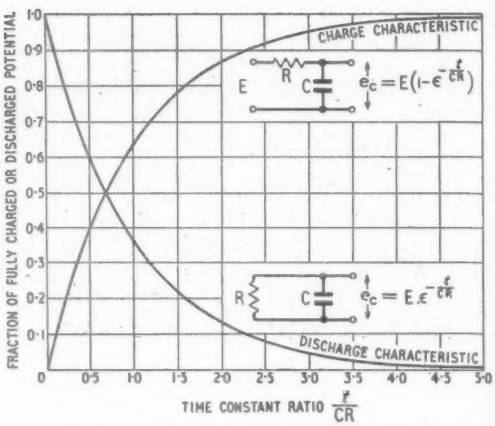


Fig. 5. Capacitor charge and discharge curves.



The ordinate therefore is plotted in units representing instantaneous fractions of the final charged and discharged capacitor potentials respectively. Using the discharge curve, $\frac{t_d}{CR_d}$ corresponds to

$$\frac{V_{g2}' - I_{a2}R_k}{V_{g2}'' - I_{a2}R_k}$$

Here t_d is the specified flyback (discharge) time, and the duration of the free anode pulse, and $R_d = R_k + V_2$ (grid-cathode impedance), say 1kΩ. The value of C may thus be calculated.

13. The charging cycle is straightforward; V_2 grid rises from V_{g2}' towards h.t. but is caught at V_{g2}''. Using the charge curve, $\frac{t_c}{CR}$ corresponds to

$$\frac{V_{g2}'' - V_{g2}'}{\text{h.t.} - V_{g2}'}$$

where t_c is the specified scan (charge) time. Knowing C from the previous calculation, the value of R can be solved.

This completes the design process, although since it is very unusual for exact values to be found for resistors R_b, R_1 and R_2 some repetition of the steps 7 to 11 may be necessary to effect an acceptable compromise between specified and obtainable performance.

The following design example serves to demonstrate that the procedure is not as laborious as might be thought. No correction is applied to the calculated values to yield a performance closer to that specified.

The specification is as follows:—

1. Amplitude of pulse (V_o) = 15V with rise time $t_r \gtrsim 0.1\mu$sec.
2. Scan amplitude (A) = 50V with peak positive level of 100V d.c.

(*Continued on page 347*)

Vortexion quality equipment

Model W.V.B.

Our specialised MONITOR HEAD MODEL W.V.B. has an additional head and amplifier which enables this recorder to perform a number of useful functions. The most important of these is to monitor the recorded tape a fraction of a second after it is made, and if necessary compare it by throwing a switch, with the signal before it is recorded. This allows the recording engineer to make certain that he has made a first-class recording before the artists leave the studio, without the necessity of waiting while another run through is made.

Additional items may be recorded one on top of another while listening to the first, since a switch is provided for the erase, and the bias, which also acts as a partial erase, can be lowered slightly, and its new value checked on the meter. In a similar manner the original signal may be fed back and recorded, resulting in an echo, the time constant of which is controlled by the speed of the tape and the distance apart of the heads.

VORTEXION RECORDERS use a synchronous capstan motor to ensure accurate recording and play back speed.

Many years of steady development have enabled us to still further improve the Vortexion W.V.A. and W.V.B. recorders which are now fitted with clock type position indicators.

All components which could contribute to noise or reliability are carefully measured and selected individually before incorporation, resulting in an exceedingly low background noise and distortion with frequency response with in± 1.5 db 50–10,000 c/s and ± 3 db 40-12,000 c/s.

★ The meter fitted for reading signal level will also read bias voltage to enable a level response to be obtained under all circumstances. A control is provided for bias adjustment to compensate low mains or ageing valves.

★ A lower bias lifts the treble response and increases distortion. A high bias attenuates the treble and reduces distortion. The normal setting is inscribed for each instrument.

★ The distortion of the recording amplifier under recording conditions is too low to be accurately measured and is negligible.

★ A heavy mu-metal shielded microphone transformer is built in for 15–30 ohms balanced and screened line, and requires only 7 micro-volts approximately to fully load. This is equivalent to 20ft. from a ribbon microphone and the cable may be extended 440 yd. without appreciable loss.

★ The 0.5 megohm input is fully loaded by 18 millivolts and is suitable for crystal P.U.s, microphone or radio inputs.

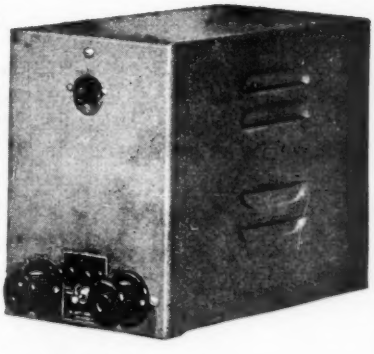
★ A power plug is provided for a radio feeder unit, etc. Variable bass and treble controls are fitted for control of the play back signal.

★ The power output is 4 watts heavily damped by negative feedback and an oval internal speaker is built in for monitoring purposes.

★ The play back amplifier may be used as a microphone or gramophone amplifier separately or whilst recording is being made.

★ The unit may be left running on record or play back even with 1,750ft. reels, with the lid closed.

POWER SUPPLY UNIT for operation with Tape Recorder or similiar equipment on 12V. car battery.



This D.C. to A.C. supply unit has been specially manufactured to provide 1% accurate 50 cycle A.C. power for 50 c/s synchronous motors and amplifiers sensitive to mains noise. The output from the 50 cycle is well filtered to reduce harmonics and give approximately the same degree of quietness as normal 50 cycle mains.

The efficiency is over 80% at wattages over 50. Terminals for a remote control switch are fitted to prevent carrying the heavy low voltage L.T. cables any distance from the battery. The unit can then be fitted at the point closest to the battery to prevent voltage drop on leads and the A.C. satisfactorily extended to any required position.

The unit is fitted in an 18 gauge steel case to give screening, but it should not be placed close to tape heads in case the field causes slight hum.

The case measures 9in. x 6in. x 9in.

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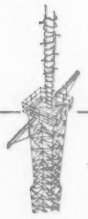
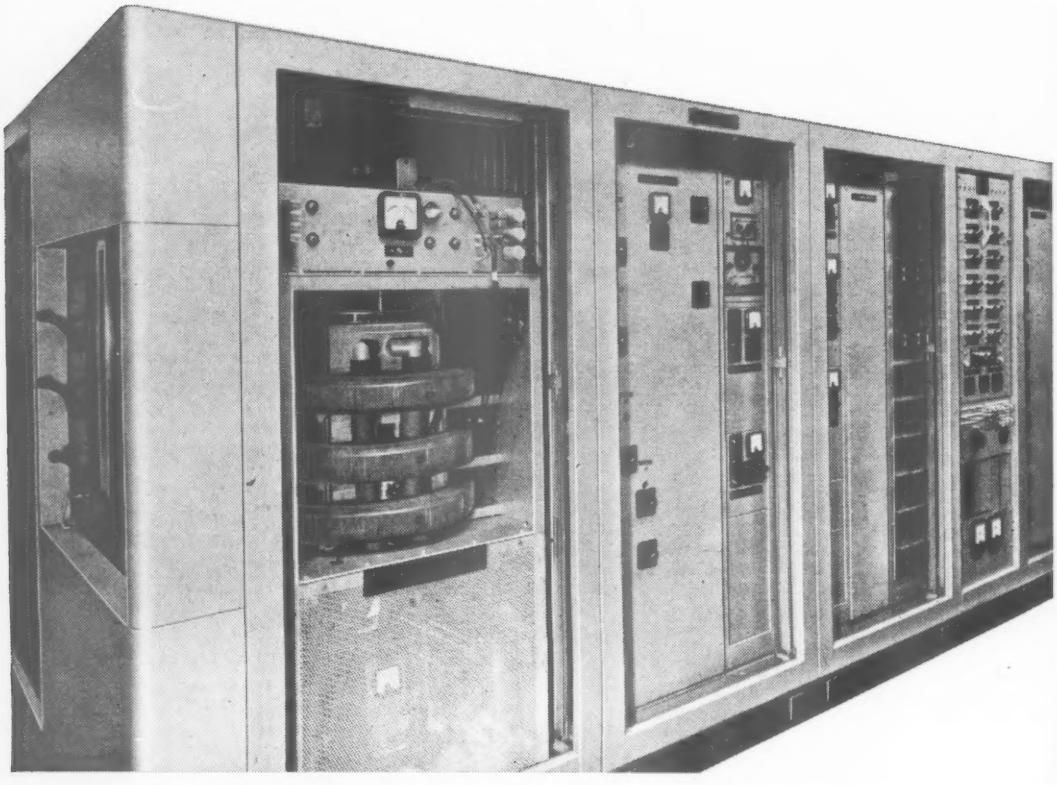


LEADERS IN TELEVISION



E.M.I., who in 1936 developed the high definition system for the first public television service in the world, has again made television history by designing and building Europe's first operational high power UHF transmitter for television.

This new transmitter, which will operate on any spot frequency in the range 470—960 Mc/s, has been installed for the B.B.C. at Crystal Palace, London, for a series of special test transmissions on Band V.

These tests are being made on both British 405-line and 625-line CCIR standards.

The equipment comprises a 10 kW Vision, a 2½ kW sound transmitter (AM or FM) and a helical aerial system which has a gain of 20.

The resultant E.R.P. taking into account losses in the waveguide is 143 kW for vision and 36 kW for sound.

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3. Scan duration (t_c) = 1200μsec.
4. Flyback time (t_d) = 100μsec.

The valve to be used is the 6J6 and the h.t. potential is 300V, while the stray capacitances at the "free" anode are estimated at 30pF.

1. $R_L = 1.5k\Omega$.
2. For V_o of 15V, $I_{a1} = 10mA$.
3. Specification requires upper d.c. level of sawtooth to be 100V, and hence cathode level will be more than 100V by the grid base of the ECC91 for approximately 300–100 volts anode-cathode.

Curves give grid base of $-$ 9V for V_{ak} of 200V.

Hence $V_k'' = 109V$

and $R_k = 10.9k\Omega$ say 11kΩ, whence $V_{g2}'' = 101V$ and $V_k = 110V$

4. For true V_k'' of 110V, V_{ak1} when conducting = 175V. Thus for $I_{a1} = 10mA$, V_{gk1} from curves = $-$ 2.9V. Hence $V_{g1}'' = 107.1V$.
5. $V_{g2}' = 101-50 = 51V$.

Assume $V_{gk2} = 0.5V$. Then $V_k' = 50.5V$.

6. $I_k = \frac{50.5}{11} = 4.6mA$.

7. Use grid current curves at $V_{gk2} = 0.5V$ to determine V_{ak2} when conducting total I_k of 4.6mA due to anode-plus grid-current:—At $V_{gk2} = 0.5V$, $V_{ak2} = 22V$, $I_{a2} = 3.9mA$, $I_{g2} = 0.72mA$.

Thus $V_{a2} = 50.5 + 22 = 72.5V$.

8. $V_{c01} = -10V$. Hence $V_{g1}' = 40.5V$.

9. $R_b = \frac{300}{3.9}\left[\frac{107.1-40.5}{107.1}\right] = 48k\Omega$ . . . say 47kΩ

10. $R_2 = \frac{47}{300/107.1-72.5/40.5} = 46.5k\Omega$ . . . say 47kΩ.

11. $R_1 = 47\left[\frac{72.5}{40.5} - 1\right] = 37.1k\Omega$ . . . say 39kΩ.

At this point it may sometimes be necessary to recalculate the levels V_{g1}' and V_{g1}'', V_{a2}, V_{k1}' and V_k'' when the approximated practical values differ widely from those of the first calculations in order that the subsequent charge/discharge circuit design is not too inaccurate.

In this instance Table I compares required and approximated ideal values, assuming zero tolerance resistors.

Continuing the design, the value of C is next calculated from the specified pulse with data.

12. $\frac{V_g' - I_{a2}R_k}{V_g'' - I_{a2}R_k} = \frac{51 - 3.9 \times 11}{101 - 3.9 \times 11} = 0.139$

Table I

	Required Level	Approximated Level
V_{g1}'	40.5	41.2
V_{g1}''	107.1	106
V_{a2}	72.5	75.4
V_k'	50.5	51.2
V_k''	110	109

From the discharge curve in Fig. 5, $\frac{t_d}{CR_d}$ corresponding to 0.139 is 1.95.

Now R_d is the sum of the grid-cathode impedance of V_2 as a diode and R_k, and is estimated at a total of 11.2kΩ in this instance.

Further, t_d from the specification is to be 100 μsec.

Therefore $C(pF) = \frac{t_d(\mu sec)}{1.97R_d(k\Omega)} \times 10^3$

$= 4570$ pF.

The nearest available value is, of course, 4700 pF. The scan time of 1200μsec is next attempted.

13. $\frac{V_{g2}'' - V_{g2}'}{\text{h.t.} - V_{g2}'} = \frac{101 - 51}{300 - 51} = 0.201$ which on the charge characteristic of Fig. 6 corresponds to a ratio $\frac{t_c}{CR}$ of 0.22.

Thus $R(M\Omega) = \frac{t_c(\mu sec)}{0.22C(pF)}$

$= 1.16M\Omega$ . . . say 1.2MΩ.

If the multivibrator is to be used principally as a scan generator then some attention must be given to linearity. In the above example, for instance, the resultant 10% linearity would not be considered good enough for many purposes.

If conventional feedback linearizing circuitry is not permitted then the scan amplitude as a percentage of the total h.t. voltage must be kept small. This requirement can be assisted by making V_{g2}' and Vg_2'' as low as is consistent with continued operation of the circuit. These considerations can assist in determining the performance specification for the circuit.

Circuit Applications.—Apart from its obvious

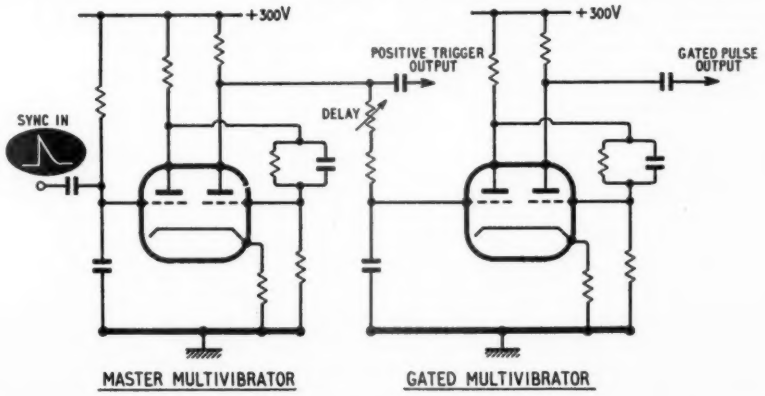


Fig. 6 Gated multivibrator for very low mark/space ratio.

use as a scan generator the circuit has other applications.

Its first recorded use[2] was in an industrial television waveform generator where in addition to generating a sawtooth it is used as a frequency divider. Here the master oscillator is controlled by a voltage derived from a discriminator which compares the master oscillator frequency, after division down to approximately mains frequency, with the mains frequency itself to establish frame lock. The master oscillator frequency, and hence line frequency, is thus maintained at a stable multiple of the frame frequency, which in turn is locked to the mains.

The multivibrator has also been used[3] in the well-known "staircase" dividing circuit, replacing the more normally encountered blocking oscillator.

Three multivibrators have been used in a circuit in which their operation is gated by three Schmitt trigger stages. The device was used as an electronic game.[4]

Two or more multivibrators can be coupled so that one gates the other. In such a connection the combination forms the basis of a useful pulse generator for waveforms of very small mark-space ratios—less than 1 : 3000. Fig. 6 shows the outline of such an arrangement.

A single multivibrator will normally tend to run irregularly at duty cycles less than 1/100. However, by designing one multivibrator to operate only when its charging grid voltage is at a higher potential than the conducting free anode potential of the controlling or master multivibrator, a gated operation results. If the limits of the gate pulse duration are set correctly, the controlled multivibrator will only produce one pulse in the gate duration. By such a means a $\frac{1}{2}$-μsec pulse at a p.r.f. of 1600 p.p.s. has been produced.

The leading edge of the gate pulse can be used as a positive trigger to an oscilloscope monitoring the fine pulse, which will then be displayed with a controllable delay. The master multivibrator can, of course, be synchronized to an external source as described earlier.

A slight variation of the basic multivibrator circuit has been described[5] which uses a triode-pentode combination to achieve similar results. In either form the multivibrator would appear to have several advantages over its oft-quoted astable partner, the cross-coupled multivibrator, and perhaps a simplified design procedure such as that presented here will assist in popularizing it.

APPENDIX

Derivation of Formulæ.—The anode voltage at V_2 is determined jointly by the current flow in the potential divider to V_1 grid and the anode current in V_2. Generally then

$$V_{a2} = \frac{R_1 + R_2}{R_1 + R_2 + R_b}\left[\text{h.t.} - I_{a2} R_b\right]$$

The two levels V_{g1}'' and V_{g1}' are a constant fraction $\frac{R_2}{R_1 + R_2}$ of the two levels at V_2 anode due respectively to no current flow in V_2 and some current flow I_{a2}. Hence

$$V_{g1}'' = \frac{R_2}{R_1 + R_2 + R_b} \text{ h.t.} \quad .. \quad .. \quad (1)$$

and

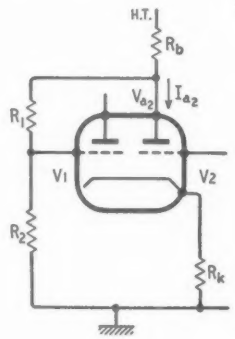
$$V_{g}' = \frac{R_2}{R_1 + R_2 + R_b} (\text{h.t.} - I_{a2} R_b) \quad .. \quad (2)$$

Subtracting (2) from (1), and dividing by (1) gives:

$$\frac{V_{g1}'' - V_{g1}'}{V_{g1}''} = \frac{I_{a2} R_b}{\text{h.t.}}$$

from which

$$R_b = \frac{\text{h.t.}}{I_{a2}}\left[\frac{V_{g1}'' - V_{g1}'}{V_{g1}''}\right] \quad .. \quad \text{formula (9)}$$



When V_2 is not conducting

$$\frac{R_2}{R_1 + R_2 + R_b} = \frac{V_{g1}''}{\text{h.t.}}$$

inverting and dividing l.h.s. by R_2 gives:—

$$\frac{R_1}{R_2} + 1 + \frac{R_b}{R_2} = \frac{\text{h.t.}}{V_{g1}''} \quad .. \quad .. \quad .. \quad (3)$$

But the ratio of resistances $\frac{R_1}{R_2}$ is the ratio of their voltage drops:

$$\frac{R_1}{R_2} = \frac{V_{a2} - V_{g1}'}{V_{g1}'} \quad .. \quad .. \quad (4)$$

and substituting this in (3) gives:—

$$\frac{V_{a2} - V_{g1}'}{V_{g1}'} + 1 + \frac{R_b}{R_2} = \frac{\text{h.t.}}{V_{g1}''}$$

from which $R_2 = \dfrac{R_b}{\dfrac{\text{h.t.}}{V_{g1}''} - \dfrac{V_{a2}}{V_{g1}'}}$ .. formula (10)

Finally R_1 is solved from (4)

$$R_1 = R_2 (V_{a2}/V_{g1}' - 1) \quad .. \quad \text{formula (11)}$$

---

[2] "Simplified Television for Industry," by R. C. Webb and J. M. Morgan. *Electronics*, June, 1950, p. 70.
[3] "An Electrical Backlash Circuit," by C. H. Banthorpe. *Electronic Engineering*, March, 1954, p. 110.
[4] "Electronic Fruit Machine," by G. L. Swaffield. *Wireless World*, September, 1957, p. 447.
[5] "Grid-Diode Saw-tooth Generator," by T. A. Mendes. *Wireless World*, December, 1957, p. 603.

BEAMA Catalogue.—The fourth edition of this massive volume of 962 pages is issued by our publishers on behalf of the British Electrical and Allied Manufacturers' Association. It includes a five-language glossary of technical terms used in the buyers' guide, which lists under more than 1,300 headings the electrical and allied equipment—including radio and electronic equipment—manufactured by members of the association. It costs £6.

Pneumatically-Operated Aerial Mast

A COLLAPSIBLE aerial mast which can be fitted either permanently or temporarily to a vehicle and quickly and easily extended whenever required is an invaluable aid in taking field-strength measurements of television or v.h.f. broadcasting stations. There are not many masts of this kind available, so that a few details of a recently introduced, British-made mast should be of more than passing interest.

The illustrations show the mast collapsed preparatory to moving to a new site and fully extended to the maximum height of 45 feet. When collapsed the overall height is only 6ft 8½in. An aerial is shown fitted to the mast, and it will support a Yagi or any alternative v.h.f. or u.h.f. aerial of reasonable dimensions and weight.

The mast is telescopic and is pneumatically operated by means of any small motor-driven air compressor capable of delivering air under pressure up to 25 lb/sq in. This is the maximum pressure required and at which the "blow-off" valve in the mast is designed to open. With an aerial weighing about 10 lb an air pressure of 10 lb/sq in is sufficient to raise the mast to its full height in a few minutes. An air bottle could be used instead of a compressor or even an ordinary foot pump would serve. The air seals are very effective and maintain the air pressure in the mast for long periods so that only occasional "topping up" is required.

This mast can be fitted in vehicles with the lowest section projecting through a weatherproof seal in the roof or on the roofs of buildings or in any location where a quickly extendable mast is required. The total weight is 125 lb and the finish is hammer grey stove enamel and cadmium plate.

We had an opportunity to witness a demonstration of the mast for which purpose it was supported on the ground and by tie rods from a small 10-cwt commercial van. To reach full height the time taken could not have been more than about four minutes. Only a tiny air compressor was used and driven from the van's engine; a larger pump, or an air bottle, would raise the mast in much less time.

During the demonstration a long extension pole was plugged into the top section, making the mast 45ft in height when fully extended. We felt that with the added top section the weight and size of the aerial would have to be carefully considered, especially when used under "gusty" wind conditions. Without an extension pole the mast is 33ft long.

Advice on matters relating to the use, fitting and capabilities of the mast is available from the makers, A. N. Clark (Engineers), Ltd., 95a Phipps Bridge Road, Merton, London, S.W.19. The price of a mast of this kind depends to some extent on the particular fittings required, but a basic figure is £190.

Clark telescopic aerial mast with dipole mounted on extension pole, also shown collapsed ready for moving to another site.

Constructed of HT30 light-alloy tube (BS1471 specification), the mast consists of seven sections telescoping into each other and tapering (by section) from 4½in outside diameter at the base, to 1½in diameter at the top. A locking device enables the two bottom sections to be locked and the mast then extends to 24ft only. The mast can be supplied with either a fixed base plate or a ball-bearing turntable base and with or without an axial key to prevent relative rotation of separate sections of the mast.

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RANDOM RADIATIONS

By "DIALLIST"

Unreliable Valves

THE letter from E. Evenson in the May issue dealing with the far-too-early failures of certain kinds of valve interested me a great deal. Some readers may recall that I pilloried the triode-pentode in these notes awhile ago. As Mr. Evenson says, failures are most frequent when this type of valve is used as an oscillator-output valve in the frame timebase. To me, it's always seemed unsound engineering practice to use a double valve of this sort in a TV timebase, where it is likely to have a heavy job of work to do. The practice may save a bit in the cost of manufacture; but too often it considerably increases the cost of maintenance to the set owner, for if one part of an expensive double valve gives out, the whole thing has to be replaced. Premature failures among valves not really up to the jobs they are called upon to do cannot do the valve-makers' reputation any good and it is surprising that they do not insist on valves being used only for work to which they can stand up.

The E.H.T. Rectifier

Another valve that can give a heap of trouble if it is overworked is the e.h.t. rectifier. I have known them run for only a matter of weeks before renewal became necessary. The trouble here is largely due to the mysterious passion of some designers for using miniature types. As a rule there is bags of room for a full-sized diode—or, at any rate, a little re-arrangement of the layout could make the necessary room. When the 12-inch tube was the largest in general use and e.h.t. voltages of about 4,000 were the order of the day, the small diode did not give much trouble. But with the very much higher e.h.t. voltages in use in to-day's 17-in and 21-in sets it can be a perfect little pest. If you are bothered by the necessity to replace your e.h.t. diode too frequently, the best plan is to discard it altogether, and to fit, or have fitted, a full-sized valve of suitable type. That seldom fails to work a complete cure.

TV Whistle

WRITING from Fayetteville, N.Y., an American reader tells me that ten or a dozen years ago the TV sets of that country often had the same irritating whistle that too many of ours assault the ears with to-day. American manufacturers, he says, overcame the trouble by potting and padding line output transformers. Ours also "pot and pad"; but they do not seem to have worked out ways of doing so as effectively as we would like. My correspondent's high-frequency auditory response must be extraordinarily good, for he tells me that, according to audiometer measurements, he can hear up to 18,000c/s. And his cannot be very young ears either, for he mentions that he has been a reader of *Wireless World* since its infant days, when it was the *Marconigraph*. I wonder how he'd like a walk through a big television showroom in this country with dozens of sets working! I do hope that all of our makers—and not just some of them—will get down to the elimination of line-scan whistle.

Television Controls

THERE is a tendency nowadays to provide fewer and fewer control knobs outside the cabinets of TV receivers. One reason for this is, I suppose, that it makes for a tidier appearance. Another probably is that a pre-set control inside the set costs less than one with an external knob. All goes well so long as it can be guaranteed with reasonable certainty that pre-set controls will continue for a long time to remain at the right settings. But too often some of them do not. Absence of external knobs is a temptation to the viewer (particularly if he has an expert friend who has once shown him how to adjust this or that) to take off the back of the cabinet and to start poking about. This can be a risky business for both viewer and set, for many of the adjustments cannot be made unless the receiver is switched on and working.

Why Not Concealed Controls?

To my mind by far the best arrangement is to provide small knobs for any controls likely to need occasional adjustment at the front of the set and to conceal them under a neat hinged panel. The set looks just as tidy as if they were inside the cabinet and with the controls at the front, adjustment is made as simple and straightforward as it could be, for you can look straight at the screen as your fingers do the necessary twiddling. This arrangement does not (or should not) tempt the viewer to fiddle about inside his set.

The Moon as Reflector

IT IS reported, I see, that signals from the United States have been received in Germany by reflection from the surface of the moon. There

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seems to be no reason why this should not be done, for radar pulses directed at the moon have been found in the course of many experiments to be returned to earth. The surface of the moon must therefore be a good reflector. But somehow I do not see that the method is likely to be of much practical use as an aid to telecommunications. The difficulties involved in aiming the wave-trains correctly and keeping them properly directed as the earth revolves could, no doubt, be overcome with no great difficulty, but high powers would be necessary to achieve a satisfactory signal/noise ratio. A bigger trouble is that to span a distance in this way the moon must be above the horizon at both the transmitting and receiving ends. If the distance is great, that cannot very often happen and the duration of the favourable conditions would anyhow be short. The suggestion that a sputnik might be used to store messages sent up from a particular point and to retransmit them when over the desired receiving end was mentioned some months ago in these notes: if a large number of artificial satellites were put into suitable orbits and kept there, might not it also be possible to use any that was in the right position at the time as a reflector?

Printed Circuitry

THERE are signs that printed circuitry will rapidly become more and more generally used in domestic sound and television sets. It has many advantages: the "wiring" of all examples of a particular model is identical; you can't have dry joints, which despite all tests at the factory are one of the serviceman's many headaches; connections can't shift so as to cause unwanted capacitance effects or such things as pick-up of hum from the frame timebase of a TV set. But it may have its teething troubles. One dealer told me that when he came to examine a broken-down set he found a section of the printed connections burnt out, though the fuses hadn't blown. I believe and hope that development will be in the direction of printed wiring, rather than printed circuitry. The receiving set of the future may consist of smallish parcels, each bearing printed connections between plug-in components. When a fault occurred any component could be pulled out for testing; if one of the connections was "dis" the panel would just be thrown away and the components plugged into a replacement. But we'll first have to make completely reliable plug-in contacts.

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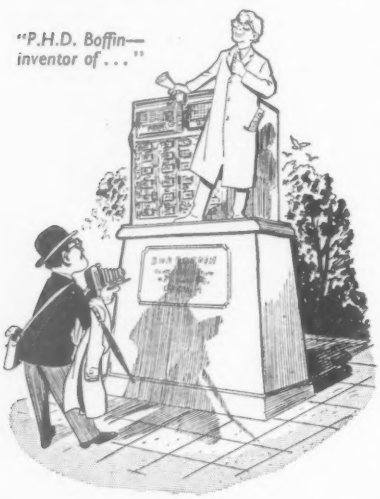
Stature and Statuary

WHENEVER I come up from the country to call on the Editor I am conscious of a distinct odour of sanctity as I pass from Waterloo to Dorset House as so many of the side streets of the district are named after bygone Archbishops of Canterbury. It always makes me wish that the pioneers of wireless could be similarly honoured and I am glad to learn that it is proposed to name a road junction near Faraday's birthplace in Southwark, "Faraday Circus." It is astonishing, however, what little honour is done to wireless and electrical men in the matter of statues.

Here and there one finds a humble plaque, such as the one to Baird in Frith Street, Soho, and Marconi in Hereford Road, Paddington, but nearly all the imposing statues are to naval and military men, politicians and statesmen, and, of course, to



"P.H.D. Boffin—inventor of . . ."

former monarchs ranging from Boudicca—known to the foreign invader as Boadicea—to George VI.

I dare say there may be one or two statues to famous electrical figures which I have overlooked but no wireless or electronics pioneer seems to have a statue. Surely a man with the stature of Marconi, who did so much for marine communications, is worthy of a statue in a naval setting like Trafalgar Square. It might, of course, be said of Marconi, the inventor of the elevated electrode, as it is of Wren in St. Paul's Cathedral, *Si monumentum requiris, circumspice.*

Maybe, of course, I am barking up a non-existent tree, and there are statues galore of the electronically eminent. If so I should be very glad to hear of them so that I can at least go and photograph them for exhibition in these columns at a later date, so I would beg you who are knowledgeable in these matters not to let me remain sunk in my ignorance.

Hints for Servicemen

AN interesting letter from a boffin of the I.T.A. calls my attention to a case where, he says, a viewer "was troubled by continuous frame roll which he could not adjust. He discovered, however, that when he switched on his water heater the frame locked in. He continued his viewing with the heater on. Later, the water reached its maximum temperature and the thermostat operated. The frame began to roll again. Our friend was not dismayed, he just ran the hot water tap until the thermostat closed and resumed his viewing uninterrupted save for an occasional dash to the bathroom to run some more hot water.

"We have advised him to re-label his hot water tap 'Frame Hold'."

I can, however, add to this bathwater story another one which occurred long before the days of TV and which I related in *W.W.* for November 18th 1932. In this case the trouble was cured when I was able to persuade a lady not to take a bath in the peak hours of broadcasting as whenever she did so she caused distortion and loss of volume to neighbouring sets.

That particular district was situated at the end of a rather long feeder and as the supply voltage was only 105, any heavy overloading of the mains caused sufficient loss of volts to bring the h.t. and l.t. supply of sets below distortion point. The lady was using an electric geyser, a type of bathwater heater not often seen nowadays as its appetite for kilowatts is more than treble that of a modern thermal storage heater.

Temporarily clearing a fault by means of shock excitation, as in the case mentioned by my correspondent in the I.T.A., is quite commonplace. I have always found it particularly effective in removing—for a time, at any rate—loudspeaker crackles caused by a dry-soldered joint somewhere in the set.

I recollect once making an elaborate sound analyser so that directly the crackles started to come from the loudspeaker they were filtered from the sound of the programme and used to actuate a Weston moving-coil relay. This operated a more robust relay which switched on a shock excitation circuit. In this manner the crackles were used to suppress themselves.

I was at the time thinking of patenting this method of A.C.C. (automatic crackle control) but I found that it wouldn't work with certain types of modern music. The trouble was that the analyser had difficulty in differentiating between the crackles and some passages of the music.

The Negatrons

RECENTLY I was reading a thrilling account of the life of "positronium" which seems to consist of an electron and a positive electron (or positron) circling round each other like a couple of boxers.

The term positive electron always irritates me as somehow it seems improper that our old friend the electron could be associated with anything like a positive charge; to use the term positron does at least cover things up a bit and reduce the insult to the electron.

I wonder if it is not high time for the term "negatron" to be used to describe the opposite of a positron. We could then reserve the honourable title of electron as a generic term to cover the whole of the great and growing "tron" family.

That reminds me that I am not at all sure that I know how many members of the "tron" family there are at the present moment. Whatever the number be now it will certainly be out of date by the time these words appear in print as "trons" have much in common with rabbits*.

[*Not only in that branch of the family which comprises elementary particles, but also in the tribe of special valves.—ED.]

Stereophony

THIS stereophonic listening business is a lot more complicated than I had supposed. In the June issue H. J. F. Crabbe mentions that if he moves his head when wearing 'phones, the whole orchestra and concert hall appear to move. When this sort of thing happens to me I usually take a couple of aspirins and lie down for an hour or so.

The announcer, during the B.B.C.'s stereo experiment in May, said that the two loudspeakers and the listener should form an equilateral triangle having sides from six to twelve feet long. It is quite obvious, therefore, that our houses need to be specially designed so that all the ground-floor rooms can quickly be turned into one large listening room. It should not be a difficult job for an architect to arrange this, and I would suggest that interior walls be of Venetian-blind construction so that they could be pulled up by an electric motor.

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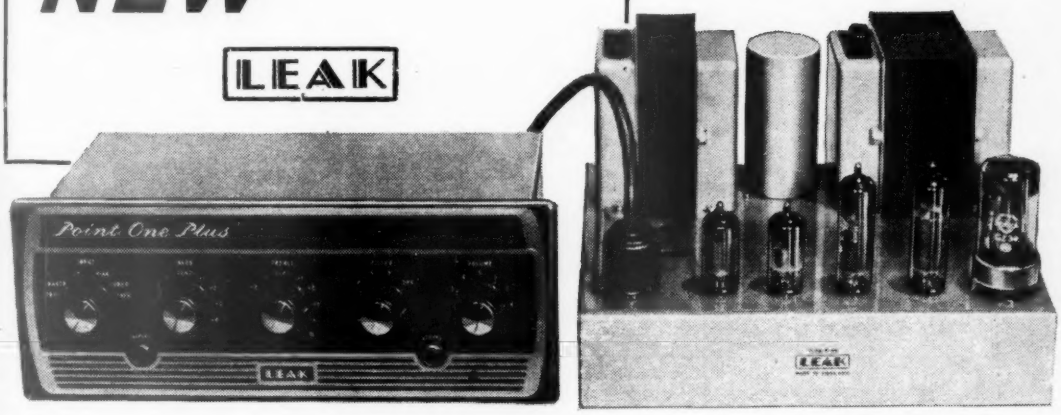

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The new Point One Plus and TL/12 Plus were exhibited and demonstrated at the New York Audio Fair and received enthusiastic consumer acceptance resulting in initial orders for one thousand one hundred and fifty sets.

LEAK amplifiers have been the choice of the B.B.C. (over 500 delivered), the South African Broadcasting Corporation (600), I.T.V. and many other Commonwealth and overseas broadcasting and TV systems, who use them for transmitting and/or monitoring (quality checking) the broadcasts to which you listen. Also, many of the gramophone records you buy are cut via LEAK amplifiers. This acceptance by professional audio engineers has led to a demand for LEAK equipment from music-lovers throughout the world.

It is appropriate here to mention one of the basic principles of LEAK design. From long experience and by extreme attention to design details during development work on the pre-production models, we enable our craftsmen to achieve a high output per man-hour. The labour costs thus saved offset the increased costs incurred for high-grade materials, components and finishes, and this together with quantity production (made possible only by a world-wide market) explains how quality products may be sold at reasonable prices.

LEAK *The First Name in High Fidelity*

H. J. LEAK & CO. LTD., BRUNEL ROAD, WESTWAY FACTORY ESTATE, LONDON, W.3, ENGLAND

Telegrams : Sinusoidal, Ealux, London
Telephone : SHEpherds Bush 1173/4/5 Cables : Sinusoidal, London

Please send details of

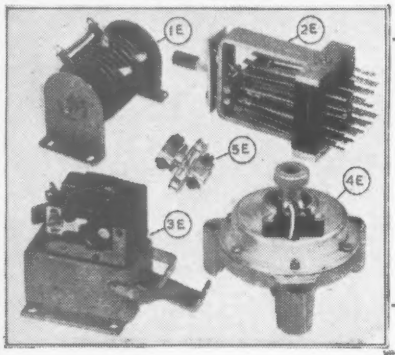
- ☐ *FM Tuner*
- ☐ *Amplifiers*
- ☐ *Gram. pickup*
- ☐ *Name and address of my nearest Hi-Fi dealer*

Name .....

Address .....

.....

WW/7/58



1E. Rectifier 36 v. ½ amp. for energising relays etc., 8/6.

2E. Key Switch Muirhead 4 change up, 4 change down reference No. C-404-C, 12/6.

3E. Cabinet safety switch double pole 15 amp. Switches off as door opens, 8/6.

4E. Electrical brake disc type, for stopping lathes, coil winders etc. Operates on approximately 100MA.

5E. Flexible spindle coupler/insulator for ¼in. spindles.

6E. Instrument type slow motion drive with locking device, 8/6 complete.

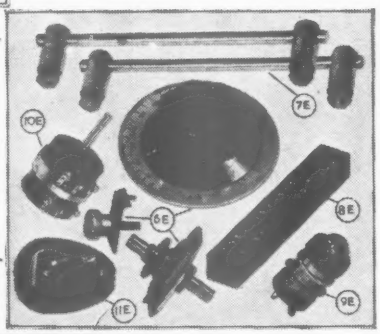
7E. Chrome plated instrument handles, 8/- pair.

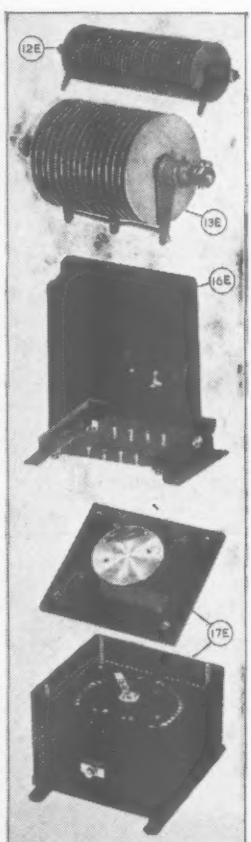
8E. Bakelite connection strip 16 way, 3/6.

9E. Indicator lamp for panel mounting, 2/9.

10E. Ganged wire wound pot value 25K ohms and 25K ohms, 6/-.

11E. Bakelite mount for 2in. plug-in meter 6/-.





12E. Selenium Rectifier 500 v. ½ amp. half wave easily rebuilt into full wave or multiple type—contain 31-45 mm. discs, 10/- each.

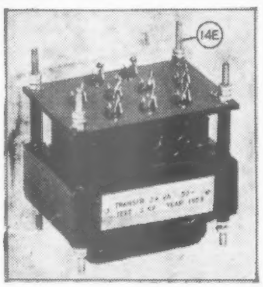
13E. Selenium Rectifier 26 v. 6 amp. full wave, easily rebuilt will make four 12 v. 3 amp. full wave charging rectifiers, 17/6.

14E. Instrument transformer primary 230 v. secondaries: 6.3 at 3/4 amp. and 2 at 85 v. at 10 mA. 8/6, plus 1/6 p. & p.

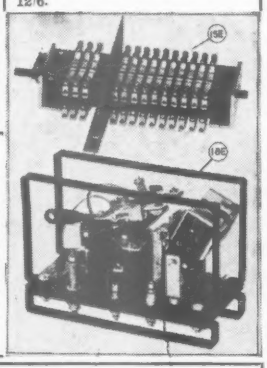
16E. Parmeko Audio transformer 4000 ohms centre tapped primary, 100 ohm secondary 17/6 plus 2/6 carriage and insurance.

17E. Dimmer or Regulator Total resistance 1,000 ohms maximum current of .59 amps. This is a beautiful unit which uses a 32 position steel switch, resistance is divided into 31 sections each approx. 30 ohms. In ventilated metal case, size approx. 7in. × 7in. × 5½in. with wall mounting brackets and large control knob, 15/- plus 2/6 post and insurance.

18E. Remote Control Contactor Double pole, rated for 30 amps. D.C. but suitable for much higher current on A.C. magnetic arch blowouts and asbestos arch shields. Coil wound for 230 v. D.C. but take turns off and it will be suitable for A.C. or if you prefer, work off A.C. with rectifier. Many applications such as remote switching of motors, banks of lamps, banks of heaters, etc., etc. Energising coil can be operated off Thermostat, Toggle Switch, Push Button or our vacuum delay switch. Size overall is 10½in. x 8in. x 4¼in. Original cost probably over £5, our price 27/6 each plus 3/6 carriage and insurance.



15E. Instrument switch multi contact, 12/6.



We wish to remind customers that with the new postage rates the minimum postage on a parcel is now 1/6. Orders for lightweight items which total over £3 will be sent post free, otherwise sufficient must be included to cover postage. Also where a postage and insurance figure is specifically mentioned then this must be included regardless, as these items have to be sent separately.

Summer Sale

7 Valve 5 Waveband Superhet Chassis. H.F. stage and magic eye. Unused but may be slightly soiled and need servicing—less valves, power pack and tuning scale. Contains really fine coil pack which alone would cost twice what we are asking for the whole unit. Price with circuit diagram **£2/15/-**. Carriage and insurance 7/6.

4 Valve Superhet Chassis. Long and medium wave complete with valves but not scale. Unused but slightly soiled and may need servicing (no data available), **29/6**, plus insurance 3/6.

10 Valve Superhet. 1½ metre ex Government but unused, complete with valves, easily converted for Band III, **39/6** carriage and packing 7/6.

Isolation Transformer 150 watt, mains in, isolated mains out, makes servicing safe. **29/6.**

Filament Transformer. 6.3 volt 3/4 amps., tapped primary, **8/6.**

Transistor. Suitable A.F. or low R.F., new tested, O.K. most circuits, **6/6.**

Midget Output Transformer. Standard pentode matching, **4/6.**

Midget Output Transformer special for battery sets, pentode matching, **4/6.**

14in. T.V. Cabinet by famous maker, cost over £4 to make, new and perfect, **15/-**, carriage 4/6.

Metal Rectifier, 250 v. 60-80 milliamps, ideal for mains set or instrument or to replace that expensive valve, **4/6.**

Constructors' Parcel, 5 valve superhet, chassis, 15 x 15 x 2 with three waveband glass scale, pulleys, drive head etc., **9/6,** plus post and insurance 1/6.

Toggle Switch, standard metal body type with round dolly, fixing ring and on/off indicating plate, **1/3 or 12/-** doz.

Weymouth Coil Pack, long, medium and two short, **19/6.**

Thin Paxolin Panels, size 8in. x 5in., 2/6 dozen.

Midget I.F. Coils. 465k/c. but with feed back winding for economy circuits, **6/6** pair.

Mains Transformer standard 230 v., input, 250-0-250 at 80 mA., 6.3 v. at 5 mA., **12/6.**

Out of Season Bargain. Enough waterproof heating element to make an average size blanket, normally sold at 15/-, price complete with illustrated data **9/6.**

50 Assorted Resistors, well mixed and useful values ½ and ½ watt, **5/-** for 50.

Ditto but 1 watt, **6/6** for 50.

.1 mfd. 350, small tubular metal cased condensers made by **Dubilier, 2/6** dozen.

Loudspeaker 8in. energised field, **9/6,** carriage 3/6.

Welding Transformer 12 v.-50 amp. continuous rating, intermittent rating for spot welding, exceeds 2,000 amps., **45/-,** carriage and packing 5/-.

Metal Rectifier equivalent of RM5 250 mA. 250 v. **12/6.**

Cathode Ray Tube VCR517 **7/6,** carriage etc. 3/6.

Thermal Delay Vacuum Relay with book of interesting circuits, **6/6.**

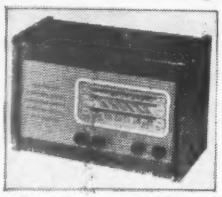
Connecting Wire P.V.C. covering all colours, sale price **2/6** 100ft. coil or 5 coils different colours **10/-** lot.

6ft. unbreakable Mains Lead. Type of lead fitted to electric razors, makes fine lead for test meters and any other devices where subject to continuous bending. Twin figure eight construction, soft cream P.V.C. covered. Normally costs 2/- per yard, we offer three leads for 2/-.

Auto Transformer. Totally enclosed, primary 200/250 v., secondary 110/120 v. rated 200/250, **27/6,** carr. & ins. 2/6.

Screened Cable. Rubber covered flexible with metal brading, ideal for microphone or gramophone extension. 4d. per yd., **30/-** per 100 yds.

Cabinet with Chassis Bargain



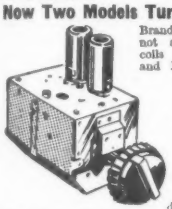
is a fine walnut veneered table receiver cabinet complete with metal chassis, three colour glass scale, back plate and scale mounts, as illustrated but less knobs. Offered at less than the price of the cabinet, namely **39/6** plus 5/- carriage and insurance.

Medresco Hearing Aid

As supplied by National Health, completely overhauled and in good working order with six months' guarantee. Only **£2.15.0** plus 2/6 post and ins. Complete with earphone and new ear plug but not batteries, these can be supplied as an extra for 5/- per set.

Instructions showing how to convert to pocket radio available free if requested.

Now Two Models Turret Tuner



Brand new stock, not surplus, with coils for Band I and III, complete with valves. Model I.—I.F. output 33/38 mc/s. Series heaters. Model II.—I.F. output 16 - 19 mc/s. Parallel heaters with circuit diagram, **79/6**.

With knobs 3/6 extra, post and ins. 2/6.

Yours for 10/- down and 17 weekly payments of 10/- or cash price £8.10.0

The latest, most up-to-date Record Player made by the famous B.S.R. Company. Using Hi-Fi Crystal Pick Up and fitted with every modern device. Definitely a record changer which will give years of trouble-free music. Not surplus but the current model. Price **£8/10/-** or **10/-** deposit and 17 weekly payments of **10/-**, carriage and insurance 5/-.

Sub-Miniature Electrolytics

These are extremely small—for instance, 1 mfd is only approx. ¼in. long by a little over ¼in. diameter. Mainly developed for transistor receivers, price **2/9** each. Special quotes for quantities. The following values available but additional types are being added almost weekly. 1 mfd. 18 v., 1½ mfd. 6 v., 2.5 mfd. 6 v., 6 mfd. 6 v., 5 mfd. 12½ v., 8 mfd. 6 v., 10 mfd. 6v., 16 mfd. 12 v., 25 mfd. 6 v., 25 mfd. 25 v., 32 mfd. 3v.

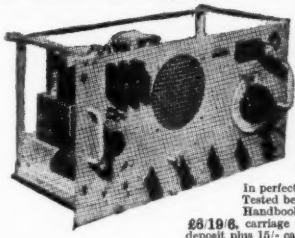
TV Masks

Latest type grey crystalliate

14in., **10/-**, 17in., **12/-**.

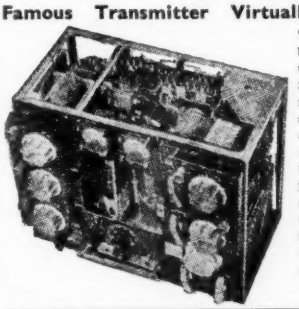
Plus 1/- Post.

Short Wave Communications Receiver R.208 for 10/- Deposit and 14 weekly payments of 10/-, or Cash Price £6/19/6.



This is a super short-wave receiver covering 5-30 metres (10-60 Mc/s). Uses 6 valves. Has R.F. stage, 2 I.F. stages, B.F.O., etc. Muirhead instrument drive, two internal power packs, mains and battery vibrator pack. Complete with own P.M. speaker. Provision for phones and speaker muting. Complete in metal transit case; size approx. 24 × 18 × 12in.; weight 70lb. Suitable A.C. mains 100-250 and 6 volt battery. In perfect condition, practically unused. Tested before despatch and guaranteed. Handbook free with each. Price **£8/19/6**, carriage and insurance 15/-. Or **10/-** deposit plus 15/- carriage and ins. then 14 weekly payments of **10/-** each.

Famous Transmitter Virtually Given Away



The famous R1154N—unused but slightly soiled and not tested. Covers 200-500 Kc/s., 3-5.5 mc/s. and 5.5-10 mc/s. Has unique "click stop" mechanism (7 stops) and permits selected frequency to be held, returned to, etc. Hartley oscillator, power amplifier, keying and speech. Wonderful breakdown value meters, relays, switches. Complete with valves—real bargain at **29/6**. Plus 10/- carriage.

THIS MONTH'S SNIP

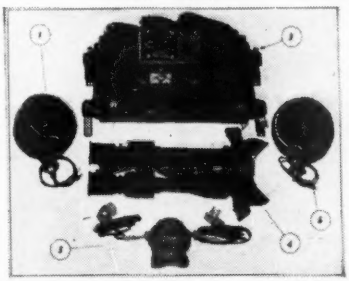
Unit No. R3206

This is a double unit of unique construction being hinged at front and opening up into two sections for accessibility of components. It contains a wealth of components, only a few of which are:— 15 moulded international octal valve holders; 3 carbon pot. meters; 1 I.F. strip suitable T.V.; 2 glass diodes; 1 crystal diode; 1 P.O. relay; 2 12-way plugs and sockets; 1 delay line; 1 11-position Yaxley switch; 1 P.O. jack; approx. 100 resistors, wire wound, carbon and high stability; approx. 50 silver mica and ceramic condensers and a wealth of nuts, bolts, clips, screen wire, pot. locks, tag strips, tag boards, knobs, valve top caps, etc. —everything useful to the home constructor. Unused but a little soiled—absolute gift at **12/6** (the nuts and screws it contains would cost this), plus 3/6 carriage.

Super Sensitive (2,000 O.P.V.) Multimeter Kit

17 ranges including D.C. volts to 1,000 volts, A.C. to 1,000 volts, D.C. milliamps to 500, ohms to 2 meg., capacity and inductance. All the essential parts including metal case, selected resistors, wire for shunts, selected switches, calibrated scale and instructions, **32/6**, plus 2/6 post and insurance.

Tabby Equipment complete

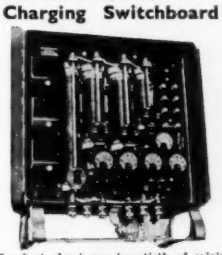


Completeequipment for seeing in the dark, as fitted to Army vehicles for night driving, etc. Complete working equipment comprises: 2 Infra Red Radiators, adjustable binoculars, powerpack for 6 or 12 volts, control units and interconnection cables. Original cost probably around £100. Unused and in perfect order—**£10** plus 10/- carriage and insurance. Mains power pack 64 extra.

Like all AVO meters it is a very fine instrument; it has a sensitivity of 10,000 ohms per volt and 19 most useful ranges as follows:—D.C. volts 0-1,000 (seven ranges). A.C. volts 0-1,000 (five ranges). D.C. Current 0-1 amp. (5 ranges), resistance 0-2 megs. (2 ranges) (complete with test leads). Immediate delivery. **Cash price £9/10/- or 10/-** deposit and 19 weekly payments of **10/-**.

FREE GIFT.—All purchasers of the above item this month will receive the M.M. Range Extender Scale and data which adds: capacity 0.1 m.r. in two ranges—inductance 0-100 henrys, etc., etc.

Charging Switchboard



Offered at about one twentieth of original cost. This is an ex Government switchboard. It contains three reverse current relays, one voltmeter, one main ammeter, two secondary ammeters and three variable resistors for controlling circuits. These are original cases. Price **£2/15/-**. Carr. 10/-.

Band III Converter

Suitable Wales, London, Midlands, North, Scotland, etc. All the parts including 2 EF80 valves, coils, fine tuner, contrast control, condensers, and resistors. (Metal case available as an extra). Price only **19/6**, plus 2/6 post and insurance. Data free with parts or available separately **1/6**.

Unused and Boxed Valves

American list, others in stock. Send us your enquiry or order C.O.D.

1A4	9/-	6C4	6/6	6TH8	12/-
1A6	9/-	6C6	6/6	6U5	8/6
1A7	12/6	6C8	5/-	6V6	9/6
1C5	12/6	6D6	6/6	6X5	7/6
1D7	9/-	6F5	9/6	6Z5	15/-
1F6	12/6	6F6	7/6	7A7	9/6
1H5	10/-	6F8	9/6	7C7	9/6
1LD5	3/6	6G6	7/6	7V7	9/6
1T4	7/6	6H6	2/6	7Y4	8/6
1R5	7/6	6J5	5/-	25Y5	10/-
1S5	7/6	6J7	6/-	25Z4	9/6
1T5	8/-	6K6	7/-	25Z6	10/6
2A5	12/6	6L5	9/-	27	10/-
2A6	12/6	6L6	9/-	28D7	3/6
2A7	12/6	6L7	10/6	36	10/-
2X2	4/6	6N7	8/6	39/44	10/-
3A4	7/-	6P8	9/-	41	9/6
3A5	7/-	6Q6	9/-	42	8/-
3S4	8/-	6Q7	9/-	43	10/-
3V4	9/-	6R7	9/-	57	10/-
5Y3	8/-	58A7	8/-	58	10/-
5R4	9/6	68C7	9/-	71	9/6
5U4	8/-	68H7	6/-	75	12/6
5Z3	15/-	68J7	8/6	78	8/6
5Z4	9/6	68K7	6/-	84	8/6
6A7	12/6	68L7	8/-	89	12/-
6A8	10/-	68N7	7/6	807	6/6
6B4	5/-	68Q7	9/-	1625	10/6
6B8	4/-	6887	9/-	954	3/8

ELECTRONIC PRECISION EQUIPMENT, LTD.

Post orders are dealt with from Eastbourne, so for prompt attention please post your orders to 66 Grove Road, Eastbourne, marked Department 2.

42-46, Windmill Hill, Ruislip, Middx.
Phone: RUISLIP 5780.
Half day, Wednesday.

66, Grove Road, Eastbourne, Sussex.
Half day, Saturday.

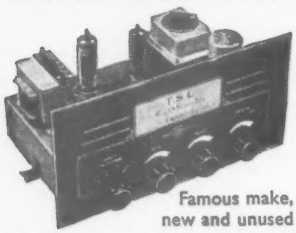
29, Stroud Green Rd., Finsbury Park, N.4.
Phone: ARChway 1049.
Half day, Thursday.

226, London Road, Croydon.
Phone: CRO 6558.
Half day, Wednesday.

LASKY'S RADIO

SAVE POUNDS! ORDER BY POST IF YOU CANNOT CALL

SUPER BARGAIN!



Famous make, new and unused

HI-FI AMPLIFIER

LISTED AT 13 GNS

LASKY'S PRICE £7.7.0 Post & Pkg. 5/-.

For mains 200/250 v. A.C.

★ 4 valves: 2 EF86, 1 EL84 and EZ80.
★ Overall Freq. Response 20 to 35,000 c.p.s. Flat approx. ±1dB.
★ Hum level better than 65dB below full input.
★ Output 4 watts max. with choice of 3 or 15 ohm imp. by means of switch.
★ Separate bass and treble controls and 4-position input selector switch.

CABINET AVAILABLE. 11½ × 6½ × 7½in. deep, polished medium oak veneer. Price, if purchased with Amplifier, 30/-.

MULLARD 510 AMPLIFIER KIT WITH T.C.C. PRINTED CIRCUIT

All specified components and your choice of transformers and chokes by Partridge, Haddon, W/B, Ellison or Gilson.

COMPLETE KIT of parts and printed circuit as low as **£9.9.0** Book 3/6 Details on request. post free.

Printed Circuit separately 22/6. Also available built ready for use. Price according to transformers used.

LASKY'S 4-WATT PORTABLE GRAM. AMPLIFIER

Will suit any crystal or magnetic pick-up. Uses 3 valves: EL84 output, L63 and EZ80 rect.

COMPLETE with 3 valves and knobs. Carr. 5/-. **79/6**

Details and circuit diagram post free.

LASKY'S PORTABLE GRAM. AMPLIFIER KIT

2 watts. Size approx. 6¾in. × 3¾in., max. height 5in. Uses EL84 output and 6X4 rectifier, double-wound transformer, tone control, output transformer, etc.

COMPLETE KIT, including valves, printed circuit, full instructions. Carr. 2/6. **49/6**

ACOS SUB MINIATURE CRYSTAL MICROPHONE INSERTS

Type MIC.17. Size approx. ¼in. square, 3/16in. thick. Brand new and boxed. LASKY'S PRICE EACH **4/6**

Post 1/-.

TAPE RECORDING SCOOP!

YOU CAN BUILD OR BUY THIS RECORDER DE LUXE FOR

The COMPLETE RECORDER (Deck, Amplifier and Speaker fitted into Case) supplied absolutely ready for use, together with Lustraphone Mike and 1,200ft. of Tape, for only **39 Gns.** Do not miss this sensational bargain!

TODAY'S VALUE 64 GNS

ONLY 39 GNS

Complete with Lustraphone Moving Coil Mike and 1,200ft. of Tape.

Carr. & Ins., 21/-.

All the component parts of this recorder are available separately as below.

COLLARO TAPE TRANSCRIPTOR, Mark III, 3-speed Tape Deck. **£17.19.6**

Carr. & Pkg. 12/6.

TAPE AMPLIFIER, complete with 6 Mullard valves, EF86, ECC83 (2), EL84, EM81 and EZ81 rectifier. Separate bass and treble controls, 2 inputs and 2 volume controls which can be mixed (also can be used separately for amplification), gram. p.u. or microphone. EM81 magic eye level indicator, also extension l.s. jack and monitor jack. Price of the complete Amplifier built and wired ready for use.

Carr. & Pkg. 7/6. **£16.19.6**

DECK AND AMPLIFIER, wired and connected. **31 gns**

Carr. & Ins. 21/-.

CASE as illustrated, solidly made of best quality laminated wood, superbly finished two-tone simulated lizard, with plastic fret, rubber feet, removable lid. Overall size: 18½ × 15½ × 7½in.

Carr. & Pkg. 5/-. **£4.9.6**

SPEAKER, 10 × 7in. elliptical. **32/6**

Carr. 2/6.

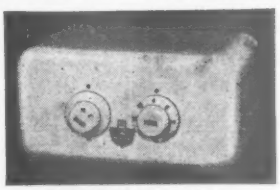
Smaller 7 × 4in. Speaker **19/6**, *can be used.*

LUSTRAPHONE "LUSTRETTE" dynamic MIKE, complete with jack, especially matched with above Amplifier. Carr. 1/6. **£3.9.6**

MAGNETIC TAPE, famous make, P.V.C. base, 1,200ft. **35/-**

Carr 1/6.

FAMOUS WOLSEY BAND III CONVERTER



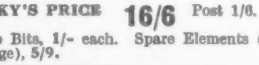
LIST PRICE £9/19/6

LASKY'S PRICE £5.19.6 Post & Pkg. 3/6.

Available on Credit Sales terms: **25/-** *deposit and 5 monthly payments of* **25/-**.

A Converter of the highest efficiency and TUNABLE OVER ALL 13 CHANNELS. Incorporates own power supply for 200-250 v. A.C. mains. 2 valves, cascode R.F. amplifier PCC84 and PCF80, metal rectifier. Handsome ivory plastic case, 7½ × 3½ × 4½in. Brand new in maker's cartons. Limited quantity only. Send today!

SOLON SOLDERING IRONS ALMOST HALF PRICE!



Ex-Govt. new and unused. Pencil bit, 65 w., 230-250 v. A.C./D.C. List 27/6.

LASKY'S PRICE 16/6 Post 1/6.

Spare Bits, 1/- each. Spare Elements (state voltage), 5/9.

TURRET TUNERS. All types in stock—Cyldon, Brayhead, Telenge, Valradio, etc., from **79/6.** Describe your set for quotation.

HI-FI SPECIALISTS!

Visit our Tottenham Court Road address for selective Demonstrations of the latest Hi-Fi Equipment.

AMPLIFIERS. Quad, Rogers, Leak, R.C.A., Pamphonic, Dulci, W/B, Armstrong A10 Mk. II.

SPEAKERS. Wharfedale, Goodmans, G.E.C., Lowther, Lorenz, Phillips.

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SPECIAL OFFER! MAGNETIC RECORDING TAPE

FAMOUS MAKE. P.V.C. base on latest type plastic spools. Not surplus but brand new, perfect and boxed. Satisfaction or money refunded.

STANDARD	Lasky's Price
1,200ft. on 7in. spool. List 35/-	21/-
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Post: 1 spool, 1/6. Orders over 70/- post free.

RADIO · TELEVISION · HI-FI · ELECTRONICS · RECORDERS

LASKY'S RADIO

TRANSISTORS

R.F. P.N.P. Junction Type suitable for medium and low freq. oscillators freq. changers and I.F. amplifiers (1.5 to 8 Mc/s). **21/-**

(Double spot—yellow and red.)

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All types of MULLARD, B.T.H., BRIMAR and GOLTOP transistors in stock.

Build it NOW!

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Note these Star features.

- ★ Printed Circuit. 6½in. × 2½in.
- ★ 200 milliwatts p.p. output.
- ★ Uses 7 Transistors and 1 germanium diode.
- ★ Ferrite rod aerial.
- ★ Fully tunable.
- ★ 6 v. operation. Very low consumption.
- ★ Choice of 7in. × 4in. elliptical or 3½in. P.M. Speaker.
- ★ Choice of cabinet.

Circuit diagram and full building instructions supplied.

CAN BE BUILT FOR

£9.19.6 Post & Pkg. 3/6

Full data and building instructions available separately, 1/6 post free.

LASKY'S TRANSISTOR SUPERHET TUNER

For construction on Printed Circuit. Size 3¾ × 3¼in. Uses 3 R.F. transistors, 1 germanium diode, 3 I.F. transformers. Ferrite rod aerial. Operates from 6 v. battery and 1.5 v. cell.

Can be built for **£5.12.9**

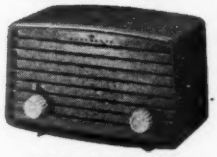
Post 3/6

Full details on request.

LASKY'S TRANSISTOR AMPLIFIER KIT

200 milliwatts. Output impedance 5 ohms. Operates from 6 v. battery. Miniature size: 3½in. × 3½in. height can be under 1in. COMPLETE KIT including 4 Transistors. PRINTED CIRCUIT full instructions. Post 3/6. Full details on request. **79/6**

LASKY'S NEW MIDGET T.R.F.



CAN BE BUILT FOR ONLY 99/6

Post & Pkg. 5/-

Handsome contemporary design case, overall size 8¼in. wide, 4¼in. deep, 5in. high. 2 latest double-purpose valves EBF89 and ECL80, contact cooled rectifier. For A.C. mains 200-250 v. Med. and long wave, 5in. P.M. speaker. Plastic cabinet in cream, pastel green, pink, blue. FULL DATA, instructions circuit diagram, shopping list 1/6. All components available separately.

CABINET only, as illus., 14/-, plus 4/6 post and pkg.

TELETRON "COMPANION"

3-TRANSISTOR POCKET RADIO. T.R.F. circuit covering med. and long waves, with balanced armature output. Ferrite aerial. Size: 4½ × 3 × 1in. ñ **89/6**

CAN BE BUILT FOR ONLY

Full instructions and price list 6d. post free.

LASKY'S F.M. TUNER

PRINTED CIRCUIT VERSION OF G.E.C. 912 "F.M. PLUS" TUNER FOR HOME CONSTRUCTION

Uses 5 valves, 9 germanium diodes and brand new T.C.C. condensers. The PRINTED CIRCUIT ensures that the I.F. and R.F. amp'lifiers are extremely stable at maximum gain and results are consistent on all tuners.

CAN BE BUILT FOR (including valves) **£7.19.6**

Post Free.

G.E.C. FM TUNER BOOK plus our full data and Shopping List, 2/6 post free. All parts available separately.

ALIGNMENT SERVICE available.

JASON F.M. TUNER

Special Parcel containing data book, chassis front panel, dial, drive, tuning condenser, full sets of coils, I.F.s, ratio detector, etc. Post 2/6. **68/9**

DATA BOOK with price list, 2/-. This tuner can be built for £6/15/-, post 3/6. Also in stock **JASON "ARGONAUT"** AM/FM TUNER and **JASON "MERCURY"** switched Tuner. Data Books 2/- each post free.

ALL TYPES F.M. TUNERS

DULCI, QUAD, LEAK, ROGERS, PAMPHONIC, etc., in stock.

DULCI HI-FI CHASSIS TUNERS AND AMPLIFIERS

Full range in stock.

SPECIAL PURCHASE! PLESSEY P.M. SPEAKERS

5in. round or 7 × 4in. elliptical. Brand new.

LASKY'S PRICE 14/6 Post 1/6

MOVING COIL P.M. SPEAKERS

2½in. 17/6. 3in. and 3½in. 19/6. 5in. 16/6. 6½in. 17/6. 8in. 21/-. 10in. 29/6. 12in. 29/6. 6½in. with transformer 21/-. 7 × 4in. 19/6. 10 × 7in. Elliptical 32/6.

TRUVOX "SENIOR" SPEAKER DRIVING UNIT (Pressure Type)

Power handling cap. 15 watts peak. With 12ft. cinema horn reproduces down to 17 c.p.s.

List £7/15/-. Carr. 5/-. **LASKY'S PRICE 59/6**

MOVING COIL METERS SPECIAL OFFERS

Brand new Grade I, 2" flush panel mounted, calibrated in decibels.

0-100 micro/A	0-200	0-500
39/6	35/-	29/6

Also, 0-1 m/A. 25/- 0-30 m/A, 15/-

2½" round projecting, 0-750 m/A, 15/- Post, per Meter, 2/6.

HI-FI ELECTROSTATIC SPEAKERS ("TWEETERS")

LSH318.....9/11 LSH100.....12/6

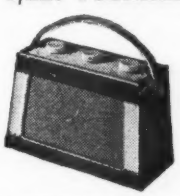
LPH65 (moving coil) 39/6.

POCKET VOLT TEST METERS. Two ranges D.C. 0-250 v. and 0-25 v. Complete with leads in leather case. 12/6, post free.

CHASSIS

We have very large stocks A.M. chassis, 1, m, s, from 7 Gns. AM/FM chassis.....from 14 Gns.

BUILD THIS 4-VALVE S/HET PORTABLE



FOR ONLY £7/7/- plus 3/6 carr. and pkg., you can build this med. and long wave Portable using all brand new components and valves, only batteries extra. Printed circuit, circuit diagram and full instructions supplied.

Circuit diagram and full data 1/6 post free.

FOR ONLY £9/9/- plus 3/6 carr. and pgk. you can build this job as a mains and battery Portable using our specially designed build-it-yourself Power Unit for 200-250 v. A.C.

COLLARO 4-SPEED MIXER AUTO-CHANGERS

Incorporating auto and manual control. Complete with Studio crystal p.u. and sapphire stylus. RC.456. List £13/17/-.

LASKY'S PRICE £7.19.6

Post 3/6.

Latest model RC.457 or "Continental" **£8/19/6.** Post 3/6.

COLLARO 4-SPEED SINGLE RECORD PLAYER

Model 4/564 complete with Studio T or O p.u. crystal cartridge and styli. Automatic stop.

LASKY'S PRICE £6.19.6

Carr. 3/6.

B.S.R.

4-speed Auto-Changer, type UA8, with crystal p.u. and ful-ñ stylus, **£6.19.6** Post 3/6.

Collaro "Junior" 4-spd. motor and p.u. with HGP59 cartridge. **90/-**

Post 2/6.

Motor only 59/6, post 2/6.

Pick-up only 29/6, post 2/6.

B.S.R. TU9, 4-speed motor and latest B.S.R. "ful-ñ" p.u. **92/6**

Post 3/6.

Delivery from stock of the COLLARO 4-speed Transcription Turntable

4T200/PX £19/10/-

Less pick-up £14/18/-. Carr. Paid.

PICK-UP CARTRIDGES

GARRARD MAGNETIC t/o, p.u. Cartridges. Type TOM/2, less than half price. **30/-**

ACOS turnover, complete with l.p. and standard styli. List £2/1/7.

LASKY'S PRICE 18/-

Post 1/-

20,000 VALVES IN STOCK

Brand new surplus and imported valves, also full stocks of B.V.A. valves and C.R. Tubes. List post free.

H.P. TERMS AND CREDIT SALES AVAILABLE

LASKY'S (HARROW ROAD) LTD.

LASKY'S RADIO

42 TOTTENHAM COURT ROAD, W.1.
Nearest Station Goodge Street
MUSeum 2605.

370 HARROW ROAD, PADDINGTON, W.9.
(Opposite Paddington Hospital)
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Open all day Saturday. Early closing Thursday (both addresses)

ALL MAIL ORDERS TO HARROW ROAD PLEASE

Stern's "fidelity" TAPE RECORDERS

THEY INCORPORATE . . .
- Choice of the latest COLLARO or TRUVOX Tape Decks.
- The model HF/TR2 "fidelity" AMPLIFIER.
- ROLA/CELESTION 10in. x 6 P.M. Speaker.
- 1,200ft. reel EMI Tape.
- ACOS Crystal Microphone.

THIS POPULAR RECORDER IS OFFERED INCORPORATING EITHER

★ The latest COLLARO TRANSCRIPTOR DECK
or
★ The NEW TRUVOX MK. IV DECK

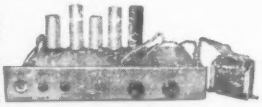
- You WON'T BUY better value.
- Truly "Hi-Fi" RECORDINGS are obtainable
- Call in and HEAR THEM, or send S.A.E. for ILLUSTRATED LEAFLET.

PRICE INCORPORATING COLLARO DECK, **£49.10.0**
CREDIT SALE. Deposit £12/8/- and 9 monthly payments of £4/10/8.
H.P TERMS. Deposit £24/15/- and 12 monthly payments of £2/5/11.

PRICE WITH TRUVOX DECK INCORPORATING REV. COUNTER, **£52.10.0**
CREDIT SALE. Deposit £13/2/6 and 9 monthly payments of £4/16/3.
H.P. TERMS. Deposit £26/5/- and 12 monthly payments of £2/8/8.
(Plus £1/10/- carriage and insurance, of which £1 is refunded on return of Packing Case.)

STERN'S TAPE PRE-AMPLIFIER and ERASE UNIT

Provides the "Link" between the HIGH-QUALITY AMPLIFIER and TAPE DECK.



MODEL HF/TR1P . . . A completely assembled Pre-Amplifier with own Power Supply. Can be supplied correctly matched for use with Truvox or Collaro Decks, and incorporates Recording Level Indicator and Monitoring facilities.
Please send S.A.E. with any inquiry.
PRICE **£11.10.0** (plus 5/- carr and insurance)

A COMPLETE KIT OF PARTS TO BUILD The "fidelity" TAPE AMPLIFIER Model HF/TR2 including a separate small POWER SUPPLY UNIT

FOR ONLY **£12.10.0** (Plus 5/- carr. and ins.)
Designed to meet the requirements of the enthusiasts for High Fidelity reproduction. It is based on the very successful design, completed by the Mullard Technicians and only new high-grade Components including MULLARD Valves are incorporated. THE ASSEMBLY MANUAL PRACTICAL DIAGRAMS, etc., are available for 2/9 or send S.A.E. for brief details.

WE ALSO SUPPLY THE FH/TR2 ASSEMBLED AND READY FOR USE FOR £16 (Plus 6/- carr. & ins.). H.P. TERMS: Deposit £8 and 9 monthly payments of £1. CREDIT TERMS: Deposit £4 and 9 monthly payments of £1/9/4.

HOME CONSTRUCTORS

BUILD YOUR OWN RECORDER — WE MAKE SPECIALLY REDUCED PRICES FOR COMBINED ORDERS — and have the following in STOCK.

★ The COLLARO TRANSCRIPTOR DECK £22/-/-
★ The TRUVOX Mk. IV Tape Deck £27/6/-. ★ The TRUVOX MK. IV DECK with Rev. Counter £30/9/-.

SPECIAL REDUCED PRICES - WE OFFER

(a)	The HF/TR2 AMPLIFIER and UNIT, fully assembled, with the TRUVOX MK IV TAPE DECK for	£38	10 0
	ALTERNATIVELY Amplifier and P/Unit KIT OF PARTS	£35	0 0
(b)	The HF/TR2 AMPLIFIER and UNIT fully assembled, with the TRUVOX TAPE DECK incorporating PRECISION REV. COUNTER	£41	10 0
	ALTERNATIVELY the Amplifier and P/Unit KIT OF PARTS	£38	0 0
(c)	The HF/TR2 AMPLIFIER and UNIT, fully assembled, with the COLLARO TRANSCRIPTOR	£35	0 0
	ALTERNATIVELY the Amplifier and P/Unit as a KIT OF PARTS	£31	10 0

Plus 12/6 Carr. and Insurance.

TO COMPLETE THE RECORDER . . . WE OFFER

The Portable Carrying Case . . . Acos
Crystal Mike . . . Rolo 10" × 6" P.M.
SPEAKER . . . 1,200ft. Plastic Tape
ALL FOR **£8.10.0** (plus 7/6 Carr. & ins.)

ADD TAPE TO YOUR EXISTING AMPLIFIER

(a)	The Model HF/TR1P TAPE PRE-AMPLIFIER together with the TRUVOX MK IV TAPE DECK	£35 0 0
(b)	ALTERNATIVELY as in (a) above but Truvox Deck incorporating PRECISION REV. COUNTER	£38 0 0
(c)	The model HF/TR1P TAPE PRE-AMPLIFIER together with the COLLARO TRANSCRIPTOR Tape Deck	£31 10 0

PLEASE INCLUDE 12/6 to cover cost of Carriage and Insurance.

HIRE PURCHASE and CREDIT SALE TERMS are available on all equipment (excluding Kits of Parts). Send S.A.E. for details.
NOTE . . . The Collaro Transcriptor is in short supply and there may be a delay in delivery. We will however book an order.
The Deck switches of the Transcriptor have to be "wired-up." We will complete this wiring, for use with either the HF/TR2 or the HF/TR1P, for an extra charge of £1

RECORD PLAYERS

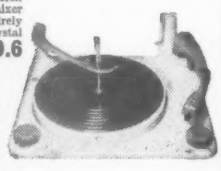
THE VERY LATEST MODELS ARE IN STOCK

MANY AT REDUCED PRICES ! ! ! !

TRANSCRIPTION UNITS—AUTOCHANGERS
SINGLE RECORD PLAYERS

Send S.A.E. for ILLUSTRATED STOCK LIST

A FEW CASH BARGAINS



- The latest B.S.R. Monarch 4-speed mixer Autochanger — entirely complete with crystal pick-up **£7.19.6**
- The latest Collaro 4-speed Mixer Autochanger — complete with the Studio "O" Pick-up **£7.19.6** Also available with the low gain Studio "P" pick-up for £8/15/-.
- The latest Collaro 4-speed Single Record Player complete with Studio "O" Pick-up **£6.19.6**
- The Collaro Junior 4-speed Single Record Player complete with separate Pick-up .... **£4.10.0** (This high output crystal pick-up is available separately for £1/12/6.)

(Carriage and insurance on above units 5/- extra.)

STERN'S "fidelity" F.M. TUNING UNIT

A 5-Valve Tuner incorporating the latest Mullard Permeability Tuned Unit. Price assembled less Power Supply.

£14.10.0

(Plus 7/6 carr. and ins.).
TERMS: (a) H.P. Deposit £7/5/- and 9 monthly payments of 18/4. (b) Credit Deposit £3/12/6 and 9 monthly payments of £1/8/7. Provides "Hi-Fi" reproduction with any make of Amplifier and many Radio Receivers. It incorporates: ● The latest Valve line-up—ECC85, 2 type EF85, EF91 and EM80. ● A "Magic Eye" Indicator. ● Power consumption is 1.7 amps. at 6.3 volts and 25 m/s at 250 volts

STERN'S "fidelity" COMBINED A.M. and F.M. TUNING UNIT

This is IDENTICAL to the Stern's F.M. Tuner illustrated above, but in addition incorporates the MEDIUM WAVE-BAND and thereby also provides a selection of foreign stations. PRICE **£18.18.0** (Plus 7/6 carr. and ins.).

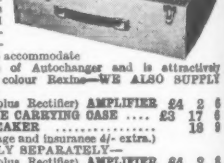
TERMS:—(a) H.P. Deposit £9/9/- and 10 monthly payments of £1/1/-; (b) Credit Deposit £4/15/- and 9 monthly payments of £1/14/7. Send S.A.E. if further data required

HOME CONSTRUCTORS . . . You can build

(a) The "fidelity" F.M. TUNING UNIT FOR **£10.0.0**
(b) The "fidelity" AM/FM TUNING UNIT for **£13.10.0**

The COMPLETE ASSEMBLY DIAGRAMS and INSTRUCTIONS CAN BE OBTAINED FOR 1/6 each.

SPECIAL CASH ONLY OFFER ! !



This very attractive PORTABLE AMPLIFIER CASE together with a good quality GRAM AMPLIFIER and a matched P.M. SPEAKER. ALL FOR ONLY **£8.7.6** (plus 7/6 carr. & ins.). The Amplifier consists of a 2 Stage design incorporating the 3 modern BVA valves and has separate BASS and TREBLE CONTROLS. The Portable Case will also accommodate almost any make of Autochanger and is attractively finished in Grey colour Rexine—WE ALSO SUPPLY SEPARATELY:—

(a)	The 2-Stage (plus Rectifier) AMPLIFIER	£4	2 6
(b)	The PORTABLE CARRYING CASE	£3	17 6
(c)	6½in. P.M. SPEAKER	18	9

(Carriage and insurance 4/- extra.)

WE ALSO SUPPLY SEPARATELY—

(a)	The 2-Stage (plus Rectifier) AMPLIFIER	£4	2 6
(b)	The PORTABLE CARRYING CASE	£3	17 6
(c)	P.M. SPEAKER	18	9

(Carriage and insurance 4/- extra.)
We also have a smaller PORTABLE CASE Ideal for Record Players. PRICE ONLY £3/3/- (plus carriage and ins.)

Open Monday to Friday 9 a.m.—6 p.m.
Saturdays 9 a.m.—1 p.m.

STERN RADIO LTD.

THE 1958 NEW LOOK MULLARD DESIGNS FOR THE HOME CONSTRUCTOR

AMPLIFIERS
PRE-AMPLIFIERS

COMPLETE KITS OF PARTS FOR THE "HI-FI" ENTHUSIAST

Designed by MULLARD—Presented by US strictly to their specification

THE VERY POPULAR MULLARD "5-10" MAIN AMPLIFIER

Undoubtedly the most successful amplifier yet designed, and used in conjunction with the new Mullard Pre-Amplifier, an undistorted power output of up to 10 watts is obtained. Thoroughly recommended to the "Hi-Fi" enthusiast who contemplates a very high quality home installation. In addition the versatility of the equipment makes it quite suitable for use in small halls, etc. We supply complete to MULLARD'S SPECIFICATION with specified valves and components and including the latest PARMEKO Ultra linear Output transformer and the Parmeko mains transformer which has power available to drive Radio Tuning Unit.

Price for COMPLETE KIT OF PARTS..... **£10.0.0**
Alternatively we supply ASSEMBLED and TESTED **£11.10.0**
(Carriage and insurance 5/- extra).

We also offer this "5-10" incorporating the latest PARTRIDGE ULTRA-LINEAR OUTPUT TRANSFORMER for £1/6/- extra.

SPECIAL PRICE REDUCTIONS—WE OFFER

(a) THE COMPLETE KIT of PARTS to build both the "5-10" MAIN AMPLIFIER and the 2-stage PRE-AMPLIFIER-CONTROL UNIT **£12.10.0**

(b) THE COMPLETE KIT or PARTS to build both the "5-10" MAIN AMPLIFIER and the 2-STAGE PRE-AMPLIFIER-CONTROL UNIT **£15.15.0**

*ALL PRICES QUOTED FOR THE "5-10" ARE SUBJECT TO £1/6/- EXTRA IF THE PARTRIDGE TRANSF. IS REQUIRED.

(a) THE "5-10" and the 2-STAGE PRE-AMPLIFIER both ASSEMBLED and TESTED..... **£15.0.0**

CREDIT TERMS: DEPOSIT £3/15/- and 9 monthly payments of £1/7/6.
H.P. TERMS: DEP. £7/10/- & 9 monthly payments of 19/-.

(b) THE "5-10" and the 2-STAGE PRE-AMPLIFIER both ASSEMBLED and TESTED **£18.18.0**

CREDIT TERMS: DEPOSIT £4/15/- and 9 monthly payments of £1/14/7.
H.P. TERMS: DEP. £9/9/- & 12 monthly payments of 17/6.

When ordering please include an extra 7/6 to cover the cost of carriage and insurance

MULLARD'S NEW 2-STAGE PRE-AMPLIFIER-TONE CONTROL UNIT

A completely new design employing two EF86 valves, and in particular designed to operate with the Mullard range of Power Amplifiers, but also perfectly suitable for other makes.

Briefly it incorporates:—

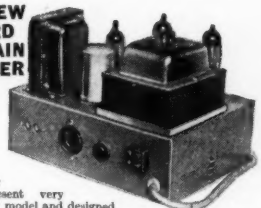
- Equalisation for the latest R.I.A.A. characteristics.
- Input for variable reluctance. Magnetic Pick-ups.
- Input for Crystal Pick-ups.
- Input for Tape replay.
  - (a) Direct from High Impedance Tape Head.
  - (b) From a Tape Amplifier or Pre-Amplifier.
- Sensitive Microphone Channel.
- Wide range BASS and TREBLE Controls
- Attractive Perspex front control panel.
- Our Kit is strictly to MULLARD'S SPECIFICATION.

Price, COMPLETE KIT OF PARTS..... **£6.6.0**
Alternatively we supply ASSEMBLED and TESTED **£8.0.0**
(Carriage and Insurance 5/- extra.)

Only NEW HIGH GRADE Components and Mullard Valves are supplied with these kits—we DO NOT use "Surplus or Cheap" components.

Please enclose S.A.E. if ILLUSTRATED and DESCRIPTIVE LEAFLETS are required . . . alternatively the COMPLETE ASSEMBLY MANUALS containing component Price Lists and practical Drawings etc. are available at 1/6 each.

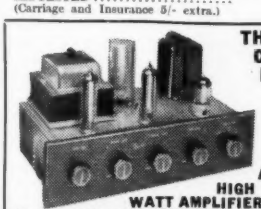
THE NEW MULLARD "3-3" MAIN AMPLIFIER



Based entirely on the present very popular "3-3" model and designed to operate in conjunction with the new 2-stage PRE-AMPLIFIER (shown here) thus providing all the facilities associated with the more expensive "Hi-Fi" equipment. We recommend it as the IDEAL SMALL HOME INSTALLATION where very high quality is desired at the lower volume level (up to 3 watts).

We supply completely to MULLARD'S SPECIFICATION INCLUDING the latest PARMEKO Output Transformer specified Valves and Components. Has Power available to drive a Radio Tuning Unit.

Price for COMPLETE KIT of PARTS **£7.0.0**
Alternatively we supply ASSEMBLED and TESTED **£8.0.0**
(Carriage and Insurance 5/- extra.)



THE NEW COMPLETE MULLARD "3-3"

A VERY HIGH QUALITY 3 WATT AMPLIFIER PROVIDING EXCELLENT REPRODUCTION AND HAVING AN ATTRACTIVE ENGRAVED PERSPEX FRONT PANEL.

Price for COMPLETE KIT OF PARTS.... **£7.10.0**
(plus 6/6 carriage and insurance.)
Alternatively supplied ASSEMBLED and FULLY TESTED..... **£8.19.6**
(plus 6/6 carriage and insurance.)

The complete specification is available for 1/6.

Developed from the very popular 3-valve 3-watt Amplifier designed in the Mullard Laboratories. Our kit is complete to the Mullard specification, including supply of specified components, valves and PARMEKO OUTPUT TRANSFORMER. We also include switched inputs for 78 and L.P. records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available.

THE NEW COMPLETE MULLARD "5-10" AMPLIFIER

We offer this popular and very successful design COMPLETE to MULLARD'S SPECIFICATION, but incorporating some improvements in the general layout. HIGH QUALITY REPRODUCTION up to a maximum of 10 watts output. The CONTROL UNIT is separate and completely enclosed; it is normally fitted to the Main Amplifier Chassis as shown in the illustration but, if it is desired to use the unit remote from the Main Chassis, it can be quite easily detached and used up to 2 yards distance. We incorporate SPECIFIED COMPONENTS and NEW MULLARD VALVES. We also give the purchaser the choice of two of the best ULTRA-LINEAR OUTPUT TRANSFORMERS made—first the latest by PARMEKO LTD., and also the latest by PARTRIDGE (£1/6/- extra) which is generally recognised as the best U/L Output Transformer made today and ensures maximum undistorted output and the widest frequency range. We also supply the PARMEKO MAINS TRANSFORMER, and this has extra power available to supply a Radio Tuning Unit amounting to 250 volts at m/a and a separate heater winding giving 4.5 volts 2½ amps.

Price COMPLETE KIT OF PARTS (PARMEKO TRANSFORMER) **£11.10.0**
Alternatively we supply ASSEMBLED and TESTED..... **£13.10.0**
Credit Sale: Dep. £3/7/6 and 9 monthly payments of £1/4/11. H.P. Terms: Dep. £6/15/- and 8 monthly payments of 19/3.
Send S.A.E. for ILLUSTRATED LEAFLET or 1/6 for the COMPLETE ASSEMBLY MANUAL.

HOME CONSTRUCTORS

BUILD YOUR OWN "Hi-Fi" LOUDSPEAKER SYSTEM

WITH W-B's WELL-KNOWN RANGE OF READY-TO-ASSEMBLE CABINETS. ALL ARE BEAUTIFULLY MADE AND FINISHED AND VERY EASILY ASSEMBLED. ONLY A SCREWDRIVER IS REQUIRED. THEY ARE PACKED FLAT IN CARTONS AND COMPLETE WITH SCREWS.

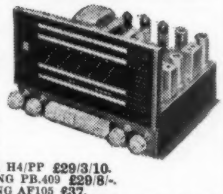
Send S.A.E. for illustrated leaflet—it contains a selection of 10 CABINETS including models to accommodate Amplifiers, Pre-amplifiers, Tuning Unit, Record Player, etc. Prices from £5/10/-. THE W.B. STENTORIAN "Hi-Fi" P.M. Speakers are also in Stock.

A COMPLETE KIT OF PARTS, STERN'S 8-10 WATT AMPLIFIER

Has power supply available for Radio Tuning Unit.
Price of COMPLETE KIT OF PARTS (plus 5/- carr. & ins.) **£7.10.0**
WE ALSO OFFER IT ASSEMBLED and READY FOR USE for **£9.10.0**
(plus 5/- carr. & ins.).

This amplifier has proved one of the most popular models yet offered to the HOME CONSTRUCTOR. It provides really excellent reproduction up to 8 watts, employing 6V6's in push-pull and incorporating negative feedback. Provides for the use of both 3-and 15 ohm Speakers. The complete SPECIFICATIONS and BUILDING INSTRUCTIONS ARE AVAILABLE for 1/6.

A Selection of RADIOGRAM CHASSIS enabling "MODERNISATION" of that OLD RADIOGRAM



ALL ARE THE LATEST AM/FM DESIGN

- The Dulci Model H.3 **£20/17/-**
- The Dulci Model H.4 **£24/6/6.**
- The Dulci Model H4/PP **£29/3/10.**
- The ARMSTRONG PB.409 **£29/8/-.**
- The ARMSTRONG AF105 **£37.**

We also have the latest FM or combined AM/FM RADIO TUNING UNITS.

- THE Dulci FM Tuner incorporating Power Supply **£17/10/3.**
- The Dulci AM/FM Tuning Unit having own Power Supply incorporated **£20/17/-.**
- The TSL FM Tuner incorporating Power Supply **£18/18/-.**

The Above are just a few examples—we have others—Send S.A.E. for full data on any chassis.
Credit Sale and H.P. Terms are available.

"FRUSTRATED EXPORT ORDER"

The Consor Model 527/X4 Valve "All-dry" Battery Portable.
Offered For **£6.15.0**
Plus 5/- carr. & ins.

Consists of a 4 valve Superhet Receiver covering Medium Waveband 197-575 metres, and two Short Wavebands 13.6 to 136 metres. The new low consumption valves are incorporated and the whole is accommodated in an attractive robustly made case. Battery required is 90 volts and 1.4 volts (price 19/6) and is external to case.

Please enclose S.A.E. with all enquiries

109-115 FLEET ST. LONDON E.C.4

Phone: FLEet Street 5812-3-4.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

CR.100 SPARES KITS

Complete set of new valves 2 X66, 2 U50, 2 DH63, 2 KT63, 6 KTW61. Also set of resistors, condensers, pots, toggle switch and output transformer. Supplied new and boxed 59/6 each. P/P. 4/6.

CRYSTAL MICROPHONE INSERTS. Only 4/6 each. P/P. 6d.

300FT. COPPER AERIAL WIRE, 3/6 reel. P/P. 1/-.

HEAVY DUTY SLIDERS. 1 ohm 12 amp, 6/6. P/P. 1/-.

AVO BATTERY ELIMINATOR POWER PACKS. Operation 200/250 volts A.C. Output 1.4 volts at 300 ma. and 67 volts at 10 ma. Stabilised by VS70, whole unit fully fused. Size 8½ × 5 × 3½in. Ideal for personal battery sets, etc., supplied brand new in maker's cartons, 39/6 each. P/P. 2/6.

AR.88 WAVECHANGE SWITCHES. Brand new, 17/6. P/P. 2/6.

P/O TELEPHONE HANDSETS. Std. type. Brand new, 12/6. P/P. 1/3.

R.1155 "N" TYPE SLOW MOTION DRIVES. Brand new, 12/6. P/P. 1/-.

METER BARGAINS.

50 Microamp. D.C. M/C, flush sq., 6in.	119/6
50 Microamp. D.C. M/C, flush rd. 2½in.	59/6
50 Microamp. D.C. M/C proj. rd. 2½in.	49/6
100 Microamp. D.C. M/C, flush rd. 2½in.	42/6
500 Microamp. D.C. M/C, flush rd., 3in.	15/6
500/0/500 Microamp. D.C. M/C, proj. rd. 2½in.	19/6
1 Milliamp. D.C. M/C, flush rd. 2½in.	25/-
10 Milliamp. D.C. M/C, flush rd. 2½in.	9/6
30 Milliamp. D.C. M/C, flush rd. 2½in.	9/6
200 Milliamp. D.C. M/C, flush rd. 2½in.	9/6
1.5 Amp. A.C./D.C. M/I flush rd. 2in.	8/6
7.5 Amp. D.C. M/I, proj. rd. 2½in.	10/6
30 Amp. D.C. M/C, flush rd., 2½in.	9/6
15 Volt D.C M/C, flush rd. 1½in.	10/6
15 Volt A.C. M/I, flush rd. 2½in.	9/6
25 Volt D.C. M/C, proj. rd. 2in.	8/6
120 Volt D.C. M/C, flush rd. 3½in.	32/6
300 Volt A.C. M/I, flush rd. 2½in.	25/-
300 Volt A.C. M/C, rectifier, flush rd. 2½in.	35/-
500 Volt A.C. M/I, flush rd., 2½in.	25/-

ALL BRAND NEW AND TESTED.

ROTARY TRANSFORMERS. American type. 2 models, either 6 or 12 volt D.C. input. Output 250 volts 80 ma. 22/6 each. P/P. 3/6.

MUIRHEAD PRECISION STUD SWITCHES. 24 positions, 4 banks. Heavy duty contacts. New, boxed, 17/6 each. P/P. 1/6. Ditto 2 banks, 10/6. P/P. 1/-.

2 VOLT 3 A.H. ACCUMULATORS. Exide, unfilled, 2/- each. P/P. 1/-. 12 for 21/-. P/P. 4/6.

AMERICAN GEARED MOTORS. American 24 volt D.C. motor with built-in precision gearbox giving twin outputs 20 r.p.m. and 6 r.p.m. Will also operate on 12 v. giving reduced outputs. Size 7 × 1¾in. Shaft dia. ¼in. Supplied brand new only. P/P. 3/-. **19/6** each.

MARCONI TF-144G STANDARD SIGNAL GENERATORS. 85 kc/s. to 25 mc/s. Reconditioned as new, with test certificate. £65 each. Carriage £1.

MARCONI SIGNAL GENERATORS TF-517.
SPECIAL OFFER
Frequency coverage 10 to 18 mc/s. 33 to 58 mc/s. and 150 to 300 mc/s. Operation 200/250 volt A.C. Supplied in good working order, only £12/10/- each. P/P. £1.

TRANSFORMERS

FARMEKO TABLE TOP TRANSFORMERS. Input 230 v. 50 cycles. Output 620/550/375/0/375/550/620 volts 250 ma. Also 2-5 volt 3 amp. windings. Size: 6½ × 6½ × 5½in. Brand new only 45/- each. P/P. 5/-.

RCA ET.4336 PLATE TRANSFORMERS. Special release, brand new in original maker's transit cases. Primary tapped 200 to 250 volts 50 cycles. Secondary 2,000/0/2,000 volts 400 ma., tapped 1,500/0/1,500 volts. Price £12/10/- each. P/P. £1.

A.C. MAINS VOLTAGE REGULATOR TRANSFORMERS. Input 230 volts. Output variable from 185 to 250 volts at a max. rating of 24 amps. Ideal for laboratory use, etc., supplied as new. £15 each. P/P. 10/-.

HEAVY DUTY MAINS ISOLATING TRANSFORMERS. Specifications: Primary 230 volts 3 amps. Secondary 230 volts 3 amps (service rating, OK 5 amps.). Ideal for laboratory or workshop use. Supplied brand new in original transit cases. £6/10/- each. P/P. 10/-.

ADVANCE CONSTANT VOLTAGE TRANSFORMERS. Input 190 to 260 volts. A.C. 50 cycles. Output constant at 230 volts. Max. rating 150 watts. Supplied brand new in original crates. £8/10/- each. P/P. 5/-.

AUTO TRANSFORMERS.
Midget 105/115/120/210/230/240 v. 20 watt, 9/-. P/P. 1/-. Small shrouded American, 110/230 v. 50 watt, 12/6. P/P. 1/6. Service type, 110/230 v. 100 watt, 15/6. P/P. 2/-. General purpose. 110/230 v. 150 watt, 21/-. P/P. 2/6 **Heavy Duty** 110/230 v. 750 watt, 69/6. P/P. 5/-.

HEAVY DUTY L.T. TRANSFORMERS. Type 1. Primary tapped 110/200/250 volts. Secondary 55 volts tapped 50 volts 10 amps. Brand new, 72/6 each. P/P. 4/6. Type 2, Primary 200/250 volts. Secondary tapped 3, 6, 9, 12, 24 or 36 volts 5 amps., 35/- each. P/P. 4/6.

FERRANTI POTTED FILAMENT TRANSFORMERS. Hermetically sealed, ceramic terminations. All new and boxed. Type 1,200/250 v. input. Output 6.3 v. CT. 5.6 a., tapped 5 v. 6.3 v. CT. 4.8 a. tapped 4 v. 6.3 v. CT. 1 a. tapped 4 v., 19/6 each. Type 2. Input 200/250 v. Outputs 6.3 v. CT. 3.3 a. tapped 5 v. 6.3 v. CT. 1 a. tapped 4 v. 6.3 v. CT. .9 a. 6.3 v. CT. .6 a., 15/- each. P/P. 2/- each type.

PARMEKO TRANSFORMERS. Input 230 volts. Output 350/0/350 volts 150 ma. 6.3 v. 4 a. 5 v. 4 a. Brand new, 32/6. P/P. 3/6. Also 350/310/0/310/350 volts 220 ma. 6.3 v. 5 a., 2 × 6.3 v. 3 a., 2 × 6.3 v. 1 a., 5 v. 3 a., potted, 49/6. P/P. 3/6.

HOOVER H.T. 11a ROTARY TRANSFORMER. Midget type. Input 12 v. D.C. Output 310 v. 30 ma. Brand New and Boxed. 22/6 each. P/P. 2/-.

"C" CORE TRANSFORMERS
Special offer, all brand new and boxed. All types have 230 volts 50 cycle input. Type 1. 510/0/510 v. 300 ma., 375/0/375 v. 100 ma., 6.3 v. 9 a., 2 × 6.3 v. 2 a., 2 × 6.3 v. 1 a., 6.3 v. 1.5 a. 6.3 v., 5 a., 5 v. 3 a., 82/6. P/P. 5/-. Type 2. 450/0/450 v. 250 ma., 2 × 6.3 v. 5 a., 2 × 6.3 v. 1 a., 5 v. 4 a., 65/-. P/P. 4/6. Type 3. 450/0/450 v. 220 ma., 6.3 v. 6 a., 6.3 v. 3 a., 5 v. 3 a., 59/6. P/P. 4/-. Type 4. 350/0/350 v. 400 ma., 25 v. 1 a., 21 v. 5. a., 6.3 v., 5 a., 6.3 v. 1 a. 5 v. 4 a., 65/-. P/P. 4/6. Type 5. 360/0/360 v. 200 ma., 360/0/360 v. 65 ma., 6.3 v., CT. 5 a., 6.3 v. CT. 2 a., 6.3 v. 5 a., 5 v. 4 a., 5 v. 3 a., 65/-. P/P. 4/6.

LEACH AERIAL CHANGEOVER RELAYS. 12 volt D.C., double pole, transmitter type. New boxed, 7/6 each. P/P. 9d.

AMERICAN SUPER LIGHTWEIGHT HEADPHONES. Res. 50 ohms. Fitted with rubber earmoulds to fit inside the ear, extremely good quality, ideal for communication receivers, etc. New and boxed. 15/- pair. P/P. 1/-.

EDDYSTONE MAINS POWER PACKS. Supplied brand new and unused. Mains input 200/250 volts. Output 175 volts 60 ma. and 12 v. 2.5 a. Double choke and condenser smoothed. 5Z4 rectifier. Housed in grey metal case. Only 32/6 each. P/P. 3/6.

BARGAIN GRAM. MOTORS. Garrard centre-drive motors complete with turntables 200/250 volts A.C. Adjustable mechanically from 0 to 45 r.p.m. Only 22/6 each. P/P. 3/-.

6-VOLT VIBRATOR POWER PACKS. Output 120 volts 30 ma. Fully smoothed, uses standard 4-pin Mallory vibrator. New and boxed. 12/6 each. P/P. 2/6.

JOHNSON TX. CONDENSERS. 500 PF variables. Brand new, boxed, 15/6 each. P/P. 1/-. New, boxed, Johnson variable inductances, 22/6. P/P. 2/6.

POTTED "C" CORE CHOKES. Brand new Parmeko 20 Henry 90 ma. 10/6 each. P.P. 1/6.

W.1191 WAVEMETERS.
Portable precision battery operated frequency check meters, coverage 100 kc/s. to 20 mc/s. Supplied complete with all valves. and 1 mc/s. Xtal and calibration charts. £5/19/6 each. P/P. 6/-.

SMOOTHING CHOKE BARGAINS. 10H, 60 ma., 4/6; 15H, 60 ma., 5/6; 8H, 100 ma., 8/6; 9H, 100 ma., 7/6; 10H, 100 ma., 8/6; 5H, 200 ma., 5/6; 20H, 120 ma., 10/6; 50H, 120 ma., 15/6; swinging choke 3.6-4.2 H, 250 ma., 10/6; 3H, 100 ma., 6/6; 20H, 50ma., 7/6; 16H, 120 ma., 10/6; 100H, 30 ma., 10/6. P/P. 1/- to 2/6.

RCA OUTPUT TRANSFORMERS. Completely potted. Centre-tapped primary, 8,000 ohms. Secondary tapped 3, 7.5, 15 or 600 ohms. Separate feedback winding. 15 watts rating. Suitable for 6L6, EL84, etc., unused, 27/6 each. P/P. 2/-.

EX NAVY SOUND-POWERED TELEPHONES. This type requires no batteries to operate and can be fitted in moments to give complete inter-communication between two points. Hand generator calling. Only 45/- each. P/P. 4/6.

ALKALINE NIFE ACCUMULATORS

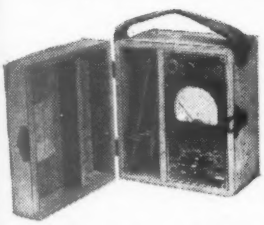
Banks of 10 cells giving 12 volts 45 A.H. Unused in wooden crates. £5/10/- each. P.P. 7/6.
Size: 26½" × 8½" × 5½".

COSSOR BEAM OSCILLOSCOPE TYPE 339

Operation 110/200/250 volts A.C. 120 watts. Time Base 10 positions. 6 cps. to 250,000 cps. Amplifier 10 cps. to 2,000,000 cps. Sensitivity, Y1.Y2.3.1 v. D.C. 1.1 v. rms. X. 2.25 v. D.C. .8 v. rms.

Supplied in good working order, complete with handbook and circuit. **£27/10/-** each. P/P. £1.

AMERICAN MULTI-RANGE TESTMETERS



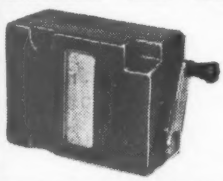
1,000 ohms per volt, 400 microamp basic movement.

A.C. VOLTS	D.C VOLTS
2.5 v	2.5 v.
10 v.	10 v.
50 v.	50 v.
250 v.	250 v.
1,000 v.	1,000 v.
5,000 v.	5,000 v.

D.C. CURRENT	RESIST'CE.
1 ma.	500 ohms
10 ma.	100 K. ohms
100 ma.	1 meg. ohms
1 amp.	DECIBELS —10 to +69

ALL BRAND NEW. COMPLETE WITH INTERNAL BATTERY, TEST PRODS AND INSTRUCTIONS. **£5/19/6** EACH. P/P. 3/-.

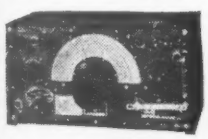
EVERSHED AND VIGNOLES WEE-MEGGERS 500 VOLTS



Special release, brand new and unused, complete with leather carrying case, only **£12/10/-** each. P/P. 2/6.

Also available secondhand models, but perfect working order complete with leather case, **£8/10/-** each. P/P. 2/6.

R.1155 COMMUNICATION RECEIVERS MODEL "N"



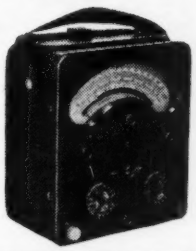
Incorporating the trawler band. Frequency coverage: 200-250 kc/s., 600-1,500 kc/s. 1.5-3 mc/s. 3-7.5 mc/s. and 7.5-18 mc/s. Supplied in perfect working order, aerial tested, with illustrated leaflet, **£12/19/6** each. P/P. 7/6. Standard models available but fitted with improved dial drive as above model, **£8/19/6** each. Combined A.C. mains power packs and output stage available. 85/- each. P/P. 3/6.

WESTON MODEL 772 TESTMETER

A.C. VOLTS	D.C. CURRENT	A.C. CURRENT
2.5 v.	100 micro/a.	500 ma.
10 v.	1 ma.	1 amp.
50 v.	10 ma.	5 amp.
250 v.	50 ma.	RESIST-ANCE
1,000 v.	100 ma.	100 ohms.
D.C. VOLTS	500 ma.	1,000 ohms
2.5 v.	OUTPUT METER	100K. ohms
10 v.		10 MEG. ohms
50 v.		
250 v.		
1,000 v.		

Supplied in perfect working order complete with rexine carrying case, internal batteries and instructions. **£10/10/-** each. P/P. 4/-.

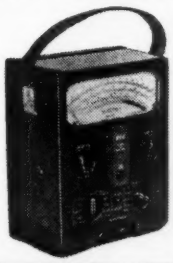
UNIVERSAL AVOMETER MODEL "D"



D.C. VOLTS	A.C. VOLTS	D.C. Current	A.C. Current
150 mv.	7.5 v.	15 ma.	75 ma.
300 mv.	15 v.	30 ma.	150 ma.
1.5 v.	75 v.	150 ma.	750 ma.
3 v.	150 v.	300 ma.	1.5 amp.
15 v.	300 v.	1.5 amp.	7.5 amp.
30 v.	600 v.	3 amp.	15 amp.
150 v.	750 v.	15 amp.	Resist-ance
300 v.	1,500 v.	30 amp.	1,000Ω
750 v.			10,000Ω
1,500 v.			

Supplied reconditioned as new, with internal battery, instructions and leads **£8/19/6** each. P/P. 4/-.

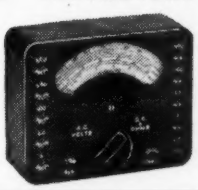
G.E.C. SELECTEST MULTI-RANGE TESTMETER



D.C. VOLTS	A.C. VOLTS	D.C. Current	A.C. Current
150 mv.	7.5 v.	1.5 ma.	75 ma.
300 mv.	15 v.	3 ma.	150 ma.
1.5 v.	75 v.	15 ma.	750 ma.
3 v.	150 v.	30 ma.	1.5 amp.
15 v.	300 v.	150 ma.	7.5 amp.
30 v.	600 v.	300 ma.	15 amp.
150 v.	750 v.	1.5 amp.	Resistance
300 v.	1,500 v.	3 amp.	10k. ohms
750 v.		15 amp.	100k. ohms
1,500 v.		30 amp.	1 meg. ohm

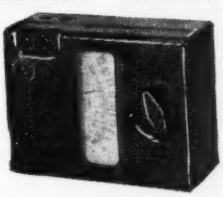
Incorporates overload trip and special safety interlocking switches. Supplied in perfect condition with leads, **£9/19/6** each. P/P. 4/-.

UNIVERSAL AVOMINOR TESTMETERS



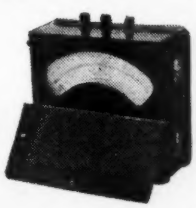
Small, compact, accurate instrument. Resistance measurements from 0 to 20 k. ohms, D.C. volts from 0 to 500 v. A.C. volts from 0 to 500 v. D.C. current from 0 to 500 ma. Supplied in perfect working order, complete with leather case and leads. **£5/10/-** each. P/P. 2/6.

EVERSHED AND VIGNOLES MEGGER OHMMETERS



Ranges 0 to 1,000 ohms and 0 to 200k. ohms. Ideal for all continuity and polarity tests. Supplied brand new, boxed with all leads and instructions, **59/6** each. P/P. 2/-.

PORTABLE PRECISION VOLTMETERS

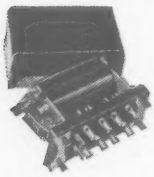


Brand new and boxed instruments by famous manufacturer. Housed in polished teak case. Moving iron movement reading A.C. or D.C. volts on 2 ranges. 0-160 v. and 0-320 v. 8in. mirror scale. Accuracy within 2%. Supplied at a fraction of original cost. Only **£5/19/6** each. P/P. 3/6.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

PROOPS BROTHERS LIMITED

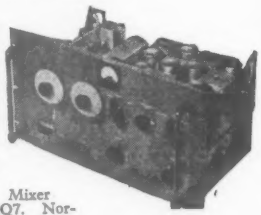


LOW VOLTAGE PRECISION RELAYS

Specially developed by a famous manufacturer to meet the rigorous demands of RAE Spec. DES1. Performance is unimpaired at 200 vibrations per sec. Actuates 2 pole changeover switched rate at 25A, from energizing potential of 24 volts, 5 watts. Change-over occurs at 16-17 volts and reverses change-over when voltage drops by one third of energizing value. Heavy-duty silver contact switch unit mounted on low-loss base. Unit protected by metal dust cover. Size 2⅛ × 1⅛ × 1¼in. Weight 9 oz. Absolutely brand new in original packing.

7/6 post free

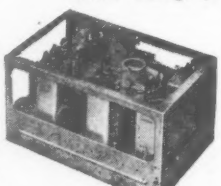
RECEIVERS



R.1392
95-150 Mc/s (2-3 Metres). 15 Valve Superhet. 1st and 2nd RF. EF54, 1st Local Oscillator SP61, 2 Oscillator Multipliers EF54, 3 IF's EF.39, AGC. 6Q7, Output 6J5. Muting EA.50, Noise Limiter EA.50, BFO.6J7, Mixer EF.54, Detector 6Q7. Normally Crystal Controlled, but can be tuned over 95 to 150 Mc/s. Power supply required = 240-250 volts at 80 mA. 6.3 volts at 4A. Standard Rack Mounting, 19 × 10in. Complete with valves and circuit diagram. Air Tested. **£6.19.6.** Carriage 10/-.

ARR3
13 Valve 60 Mc/s. FM Receiver which can easily be converted to receive B.B.C. transmissions—many supplied by us to B.B.C. engineers for their personal use. 1st and 2nd RF, Mixer, Osc., 1st, 2nd and 3rd IF's all 12SG7's. Limiter and Detector 12H6. 1st AF 12SQ7. Output 12A6. A.F.C. 2 × 12SH7. Magic eye 12U5G. Utilizes Foster Seeley discriminator. Complete with circuit diagram and full conversion instructions. **£6.0.0.** Carriage 7/6

RECEIVER UNIT EX.1143A



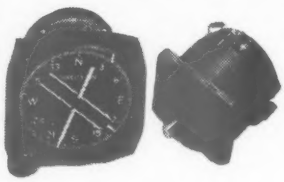
Suitable for conversion to 2 Metres or Wrotham FM transmissions.
Valve line-up: Four EF.50's; One EL32; Two EF.39's; One EBC.33; One EA.50. Circuit diagram supplied with each unit. Complete with valves. **£1.5.0.** Carriage 3/6.

AN/APNI TX/RX
Frequency modulated by moving coil transducer — heart of famous W.W. Wobbulator. Freq.: Receiver, 400-450 Mc/s. Transmitter 418-462 Mc/s. Easily converted for radio control or 70 cms. Complete with 14 valves, 4-12SH7,3-12SJ7, 2-12H6, 2-955, 2-9004 and 1-VR150. Contains a host of first class components including relays and close tolerance resistors. Brand new, at less than breakdown price.

£1.10.0
Carriage 7/6

SIGNAL GENERATOR AND WAVEMETER Type W 1643
In copper lined case. Freq.: Sig. Gen. 140-240 Mc/s. (tolerance 0.5 Mc/s.). Wavemeter 150-235 Mc/s. (tolerance 0.2 Mc/s.). Complete with valves 4 VR91 and 1 VR135, and 5 Mc/s. crystal. Requires 6.3v and 120v power supply. **£2.10.0.** Carriage 10/-.

CHEAPEST EVER REMOTE ANTENNA INDICATOR



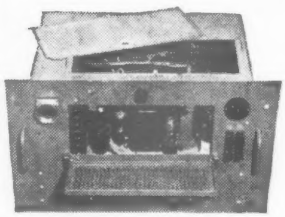
Consists of an indicator and transmitter connected by simple wiring to make a really first class remote indication system. Ideal for Antenna orientation indication, and also for use as a wind direction indicator, or for any device where positive remote indication to within 1° is required. Can be related to magnetic or geographic North, or vertical inclination. Brand new, with instructions.

£1.10.0 post free.

INDICATOR
Flush mounting, precision instrument type meter with 3in. dial calibrated 360° in 2° steps. Black crackle finish. Size 3¼ square x 3¼ inches deep.

TRANSMITTER
Specially wound potentiometer in sealed die-cast housing. Drilled ¼ inch spindle facilitates connection to almost any rotating mechanism. Operates from any 6 v.-30 v. D.C. supply. Size: 2½ square × 3in. long.

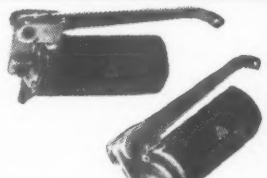
Tx POWER PACK AND MODULATOR BARGAIN



Superb, heavy-duty, power unit and modulator of "36 Sender." Fully-screened chassis housed in handsome oak cabinet with slide-out front; size 24½ × 16 × 15in. Weight 120 lb. Complete with built-in speech amplifier, push-pull 807 modulator (less trans) and separate power supplies for V.F.O., Bias and P.A. Valves: 3 × FW4500, 3 × 6C5G, and 2 × 807. Input: 100/110 v. and 200/250 v. 50 c/s at 350 watts. Outputs: 200-0-200 v., 50 mA., 2 × 500-0-500 v., 200 mA., 6.5 v. 8 A. (c.t.) and 3 × 4 v., 4 A. Circuit diagram supplied.

£6.0.0 Carriage 15/-.

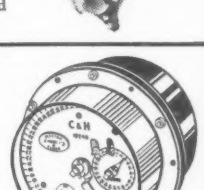
12 VOLT SOLENOID



Powerful solenoid with lever mechanism giving a mechanical advantage of approx. 4:1 (¼in. travel = 1in. arm). Consumption 350 mA. Ideal for remote controls, model railways and mechanical indicators. Bargain offer.

3 for 10/- post paid

ELECTRIC TIME SWITCH



4½-6 v. battery driven precision clock. Current negligible. Can be set to operate at any period between 15 minutes and 44 days. Ideal for automatic "lighting-up" of parked cars, etc., and many other uses. In plastic case.

12/6 post paid

PENCIL SOLDERING IRONS

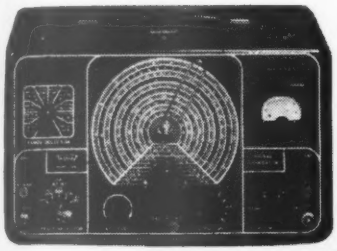
Brand new SOLON 65 watt pencil bit soldering irons. **16/6** post free Interchangeable angled bit **1/6** each.

Low-voltage, Halogen-Quenched, highly sensitive GEIGER-MUELLER TUBES— 55/- each

Straight from production, individually tested, fully guaranteed.

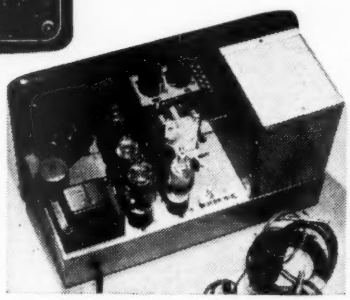
Effective length 11.8 cm. Standard British 4-pin base.
Background count 90/min
Plateau: Minimum length 80 v. Slope 5% per 100 v.
Working potential: 400-450 v.
Current: .01 μA to 1 μA at 100 to 6,000 c/min.
Response: Exceeds 30,000 c/m.
Dead time: 10μ sec. at 6,000 c/m.
Rise Time: 5 to 10μ sec. at 6,000 c/m.
Temperature range—55°C to +60°C.
Gamma Efficiency 1%. Stainless iron electrode.

The Walk-Around Shop



TRIPLETT 1632 Combined SIGNAL GENERATOR

and CRYSTAL CALIBRATED FREQUENCY METER



100 kc to 120 Mc ON FUNDAMENTALS

Special features

Six valves: 6J5, 6SA7, 6F7, 6F8, 80, VR.150.

Voltage regulated supply for stability.

Buffer amplifier to avoid oscillator " pulling."

Variable carrier level, valve metered.

Separate variable high-level RF output set against 100μA meter.

Variable output level (0-45 db attenuation) plus five step ladder attenuator (approx. 20/40/60/80 db) with each step in an individually screened compartment.

Audio Output, 4 v. at 400 c/s.

Dummy aerial with 3 switched circuits on 5ft of co-ax.

External modulation up to 5 Mc/s. 1.4 v. for 30%.

Provision to match new crystal or change marker frequency.

Two-speed, backlash-free tuning over directly calibrated scale.

Copper plated chassis, heavy screening, mains filter.

Covers: IF's, Med. Wave, HF and VHF (FM) frequencies, and all B.B.C. TV (ITV and 2 meters on 2nd harmonics).

This exceptionally favourable purchase by Proops Brothers provides a rare chance to obtain a fine piece of equipment for only

£13-10-0

Carriage paid. Complete with instruction book and leads, in attractive carrying case. In tip-top used condition. For 105-125 v. 50-60 c/s. mains. Tested before despatch.

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Phone.: LANgham 0141 Shop hours 9—6 Thurs. 9—1 **OPEN ALL DAY SATURDAY**

Carriage prices quoted apply to England & Wales only.

ROOM THERMOSTATS
By a famous manufacturer. Voltage 0/250 v., maximum current 15A. Temperature control range 50°F to 80°F. Contemporary design in cream hammer finish, complete with wall fixing plate and full installation instructions. Brand new. 15/-. Carr. 2/-.

TRANSFORMERS 230-250 volts 50 c/s.
Heater 6.3v, 1.5A, 6/6, plus 1/- carr. **Miniature mains** 230v at 40 mA and 6.3v at 1.5A, 12/6, plus 1/- carr. **Charging** 9v and 17v at 3A, 15/6, p.p. **Mains isolating** 250v/220v or 250v/110-0-110v out OR double wound auto 250v in, 110v out, 5/-, carr. 1/6. **Heavy duty mains changing** (Admiralty Pattern). Primary screened from secondary. Totally enclosed in 7 × 6 × 8in. black steel case—terminals inside lid. £1.0.0. p.p.

OUTPUT TRANSFORMERS
Plessey standard miniature output transformers. Ratio 45 : 1 and 55 : 1 4/6 p.p. Please state ratio required.

FULL-WAVE CHARGING RECTIFIERS—
24v 1.5A. 12/6, p.p.

LOUDSPEAKERS
Tannoy waterproof external 8 watt unit 7½ ohm impedance. Complete with matching transformer. Brand new, £1.0.0, plus 3/6 carr.

HEADPHONES
High resistance balanced armature £1.0.0. p.p.
Low resistance balanced armature 8/6 p.p.

MICROPHONES
Acos crystal inserts, 4/6 post paid. American throat microphones type T.S.300, including socket, 3/- post paid. Aircrew type electro magnetic microphones with switch, 2/- post paid. Carbon type in black crackle case, 12/6 post paid.

R.F. UNIT
Freq.: 200 Mc/s. With 3 956 valves. Size 8 × 3 × 4in. 15/-. p.p.

MINIATURE I.F. STRIP—9.72 Mc/s.
Complete and unused with circuit, less valves—2 EF92, 3 EF 91, 1 EB 91. 12/- p.p.

MULTI-RANGE TEST METER
Ranges 0–1.5v, 0.3v; 0–60mA; 0–500 and 0–5000 ohms. Easily read open scale. Simply extended to provide useful pocket fault finder. Size 2½ × 3½ × 3¼in. Brand new 8/6. Carr. 1/6.

GYRO UNIT AND INVERTER
Can be used as 12 v. D.C. motor for models; ideal also for experimentation and gyro demonstration purposes. Inverter: 12v DC input, 3-phase 190 cycle output. Size 4 × 4 × 3in. Gyro unit: operates on 3-phase output from inverter. Peak speed 11,400 r.p.m. Caged. Precision made equipment. 12/6 per pair. Carr. 3/-.

DYNAMOTOR
Brand new, boxed U.S. Dynamotor. 28 v. DC input, 330 v. 170 mA output. Fully smoothed by screened choke/condenser filter unit in base. Dynamotor size 3¾ × 6in. Black crackle finish 17/6 p.p.

APN1 TRANSDUCER
The heart of the W.W. TV wobbulator (described on page 252 of June 1956 issue). Brand new, 7/6 post paid.

RADIO ALTIMETER
5 mA panel mounting with 3in. dia. 8in. circular scale. Basis for sensitive multimeter. Brand new, boxed, 7/6, post paid.

ANTENNA RELAY UNIT
Contains 2½in. panel mounting 2 mA meter with separate thermocouple for measuring R.F. and change-over relay. In metal case 3½ × 4¼ × 3½in. with ceramic stand-off terminals, 12/6, post paid.

BOLT CROPPERS
9in. long, extremely powerful, 2/6 post paid. Folding type 18in. long—will cut through ¼in. bolt or cable, 7/6 post paid.

CONNECTOR BLOCKS
G.E.C. Standard 12 way " chocolate block " connectors, 3 for 6/6 post paid.

POCKET MARCHING COMPASS
In black plastic case with sighting reflector inside lid and automatic pointer lock. Luminous dial, pointer and sighting lines. Brand new, with instructions, 12/6, carr. 1/-.

TANK PERISCOPES
American type—7/6 post paid.

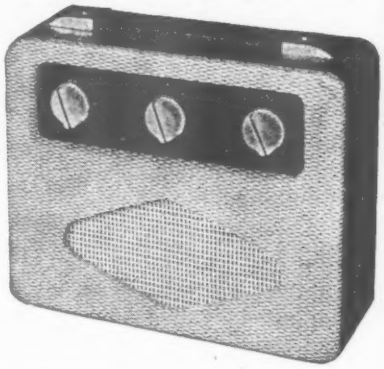
SIGNAL LAMPS
24 v. Sealed Beam Units, 16/6 post paid.

ASTRO COMPASSES
Brand new in transit case, 23/- post paid.

DRIFT SIGHT Mk. 4A
13in. long × 1¾in. dia. In wooden case, 12/6 post paid.

GROUND POSITION INDICATORS
Contains 24 v. motor and follower motors, large quantity of gearing, etc., 35/-, post paid.

THE NEW "TRANSISTOR–8"
COMBINED CAR-RADIO / PORTABLE
PUSH-PULL SUPERHET

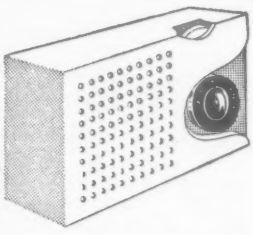


This Portable 8 Transistor Superhet is tunable for both Medium and Long Waves and is comparable in performance to any equivalent Commercial Transistor Set. Simplified construction enables this set to be built easily and quickly into an attractive lightweight cabinet supplied.

TEN STAR FEATURES
- ★ 8 Specially selected Transistors
- ★ 250 Milliwatts Output Push-Pull
- ★ Medium and Long Waves
- ★ Internal Ferrite Rod Aerial
- ★ 7 × 4 Elliptical Speaker
- ★ Drilled Plastic Chassis of 8½ × 2½in.
- ★ Point to Point wiring and practical layout
- ★ Economical. Powered by 7½ v. battery
- ★ Highly sensitive
- ★ Ideal car radio

Car Radio Conversion Components, 8/- extra.

We can supply all these items including Cabinet for **£11/10/-**. All parts sold separately. Send for circuit diagrams, assembly data, illustrations and instructions, and full shopping list.



Size 5⅛in. × 3½in. × 1⅛in.

MINI–7 POCKET TRANSISTOR PORTABLE
ULTRA SENSITIVE! ECONOMICAL!
HIGHLY SELECTIVE! WELL RECOMMENDED!

MAY BE BUILT FOR ONLY **£9'19'6**

SPECIAL FEATURES
- ★ 7-selected Transistors
- ★ Operates from 6 v. Battery
- ★ Ferrite Rod Aerial
- ★ Drilled Chassis
- ★ Practical Layout
- ★ Medium Waves
- ★ Long Waves 10/6
- ★ Attractive Plastic Case

This superhet is superior in performance to most commercial transistor sets and costs less than half the price.

All components as specified can be supplied at an inclusive price of ..... **£9/19/6** P. & P. 2/6

Send for free instruction booklet and prices.

TRANSISTORS JUNCTION TYPE PNP
(BRITISH MANUFACTURE)

RED SPOT 800 kc/s audio amplifier	7/6 each
WHITE SPOT 2.5 Mc/s osc./mixer, IF amp.	15/- each
XC101 matched pairs for up to 300 Mw	60/- per pair
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XA102 8 Mc/s osc./mixer	40/- each
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Standard 3ft. cord	3/6
2½ft. cord with moulded sub.-min. jack plug including socket	12/6
Miniature low impedance hearing aid with cord, ex-Govt.	10/6
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Miniature 2½in. Elac speaker 10 ohms	27/6
Miniature 2½in. Celestian speaker 3 ohms	27/6
Miniature 2½in. Plessey speaker 3 ohms	15/-
7 × 4in. elliptical 3 ohms	20/-
120 ohm centre tapped 7 × 4 elliptical	30/-
Other types of speakers in stock.	
Perdio 2½in. 3 ohm : 1 inch deep	27/6

Sub-miniature transformers, including push-pull types, switches, volume controls, coils, resistors, chokes, IF transformers, etc., for transistor circuits in stock. Also various types of ferrite aerials wound and unwound. Send for the free transistor components list.

JUST ARRIVED!
NEW BOXED VALVES

EQUIVALENT TO FOLLOWING TYPES

AC/SG	DDT4	MVS/PEN	PEN4VA	VMS4
AC/SGVM	FC4	SP4 (7)	PEN36C	VP4 (7)
AC/PEN	CY1C	MVS/PEN(5)	PP36	VMP4G
AC/VP1 (7)	H30	MS/PEN (7)	S4VB	VP4 (5)
AC/VP1(5)	ID5	MS/PEN(5)	SP4 (5)	VP4B
AC/VP2	MS4B	MVS/PENB	UR1C	W42
AC/HLDD	MHD4	MX40	TDD4	7D6
	MKT4		U30	7D5
				41MPG

10/- each also AZ31 12/6

SEND FOR FREE VALVE LIST

"373" MINIATURE IF STRIP 9.75 Mc/s

The ideal F.M. conversion unit as described in "P.W." April/May, 1957. Complete with 6 valves, three EF91's, two EF92's and one EB91. I.F.T.'s etc., in absolutely new condition. With circuit and conversion data.

12/6 (less valves) **42/6** (with valves)

Postage and packing 2/6 (either type).

FM AT ITS CHEAPEST!

NEW!
U.S.A. DYNAMOTORS
12 v. input, output 220 volt. 100 mA. **32/6**

Send 3d.—28-PAGE CATALOGUE CONTAINING BARGAINS IN VALVES, COMPONENTS AND METERS

HENRY'S RADIO LTD.

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"EAVESDROPPER" THREE TRANSISTOR POCKET RADIO

(No Earth or Aerial required in areas of good signal strength.) Variable tuning on medium waves. Total cost as specified, including Transistors, Transformers, Coils, Condensers and Battery, etc., with circuit and plastic case. All items sold separately. Full practical layout diagrams, **70/-** post free. With balanced armature earpiece **73/6**
With Min. Hearing Aid **86/-**

MINI-TWO TWO TRANSISTOR MINIATURE POCKET RADIO

The smallest Transistor set offered on the market. Variable tuning. Drilled chassis, plastic case 3 x 2 x ¾in., Miniature Hearing Aid, 2 Transistors and all components including 3 volt battery, circuits and full practical layout diagrams. All components sold separately. Total cost **47/6** complete.

TRANSISTOR SIGNAL TRACERS. Complete Kit with 2 Transistors, Components, Phones and Circuit and plastic case ... **37/6**

TRANSISTOR SQUARE WAVE GENERATOR. Complete Kit with 2 Transistors, Components, Circuit and plastic case **20/-**

"HOMELIGHT" TWO TRANSISTOR PERSONAL PORTABLE

Variable tuning. We can supply all components, including two Transistors, Diode, Resistors, Condensers, Miniature Hearing Aid, Plastic case, Practical layout, drilled chassis and battery for **50/-** All item sold separately

HOMELIGHT III

As above but with extra stage increasing output. Complete with 3 transistors, etc. **58/6**

TRANSISTOR PUSH-PULL AUDIO AMPLIFIER

(200 Milliwatts Output)

Build this Push-Pull Amplifier which is ideal for Crystal or Magnetic Pick-up Amplification, Baby Alarm, Microphone, Amplifier, etc. Powered by 6-volt dry battery lasting for months.

Complete kit of parts including four Transistors and all Components with Circuit and Plastic Case (less Speaker)

69/6 P.P. 2/6

QUARTZ CRYSTALS

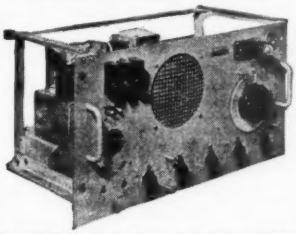
FT243 and FT241 **5/-** EACH
100 kc/s-27 Mc/s. Also available. Send for lists of frequencies.

Sputnik Special

SHORT-WAVE COMMUNICATION RECEIVER

10-60 Mc/s (5-30 Metres)

RECEPTION SET TYPE 208



Containing 6 valves, 2-6K8G, 2-EF39, 7Q6G and 6V6G, Metal rectifiers, built-in mains pack and 6 v. Vibrator pack, built-in 6½in. speaker. Muirhead slow motion drive, B.F.O. and R.F. stage. 2 Mc/s I.F. freq. Provision for 'phones and muting and 600 ohm line.

Input 100/250v. A.C. 6v. Vibrator pack supplied for battery operation.

£6/19/6

Carr. 15/6.

In new condition and air tested.

BE PREPARED TO LISTEN TO THE SATELLITES

TRIPLETT A.C./D.C. POCKET TEST-METER TYPE 666H

15 ranges 1,000 ohms per volt

In new condition with Prods and Internal battery

A.C./D.C. 10/50/250/1,000/5,000 volts.
Milliamps 0-10/100/500.
Ohms 0-300/250,000.

£5/10/-

OTHER TYPES IN STOCK

CATHODE RAY TUBES

VCR138A with screen	£1	15	0
VCR139A	£1	15	0
VCR97. Full T.V. picture (carr. 2/-)	£2	0	0
VCR517C. Full T.V. picture	£1	15	0
MU-METAL SCREENS for VCR97 or 517		10	0
3BP1. Brand new	£1	10	0

AC/DC 220/250v. PORTABLE-GRAM AMPLIFIER

Completely assembled on Baffle Board size 12½ x 4½in. Depth 3in. Containing two Mullard Valves types UL84 and UY85. Elac 7 x 4 Elliptical Speaker. Volume Control, Tone Control. Nothing else to buy, just plug in to Mains and connect your Pick-up to Amplifier.

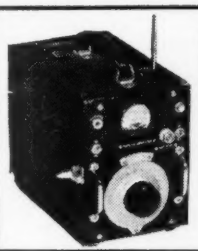
Absolute Bargain **67/6** Carr. 2/6

500 v. EVERSHED WEE-MEGGERS

New condition, with leather case £8 19 6
Brand new, with leather case..... £12 10 0
100 v., new condition, with leather case £6 0 0

U.S.A. R.F. WATTMETER TS/87/AF

Three position 0-10/15/30 watts. Complete with photo-cell, 2 spare lamps and leads, with transit case.
BRAND NEW **£10/10/-**



BC 906D FREQUENCY METER

Range 150-235 Mc/s. New condition.

45/-

5 VALVE THREE WAVE BAND PORTABLE RADIO

This chassis is A.C./D.C. and has an internal aerial and gram. switching. Size 10in. x 4in. x 10in. **£7.12.6** P.P. 7/6

WAVE-GUIDE WATTMETER

Type W8921 10 cm. Complete in transit case.
BRAND NEW **£5/10/-**

TEST SET 229

Admiralty type 600 Mc/s. Complete in transit case.
BRAND NEW **£5/10/-**

RT10/APS-3

3 Centimetre Radar Unit

Containing 725A Magnetron, 2—723A/B's, 2—6AC7's, 724A, IN23, magnet and pulse trans.
BRAND NEW IN CARTON **£10/10/-**

PIRANI HIGH-VACUUM TEST EQUIPMENT

with calibrator and galvo.

£33/10/-

SEND FOR BOOKLET

U.S.A. TESTMETER TYPE "834-S"

AC/DC 15—RANGES F.S.D. 1,000 O.P.V.
AC/DC Volts 12/60/300/600v./1,200/6,000v.
Milliamps 1.2/12/60/600 mA.
ohms 0-5,000/5 meg. **£6/19/6**
Complete in wooden carrying case with leads and internal batteries.

WALKIE/TALKIE TYPE 38 TRANSMITTER/RECEIVER

Complete with 5 valves. In new condition. With circuit. These sets are sold without guarantee, but are serviceable. P.P. 2/6. **22/6**
H/phones 7/6 pair. Junction box 2/6. Throat mike 4/6. Canvas bag 4/-. Aerial Rod 2/6.

Send 3d.—28 PAGE CATALOGUE CONTAINING BARGAINS IN VALVES, COMPONENTS AND METERS

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RC1.A AMPLIFIER. A small high-quality gramophone amplifier employing the latest circuitry and highly efficient miniature valves. Very neat chassis finished in bronze stove enamel. Size (overall) 5½ × 4 × 5in. Valve. 6X5, ECL82. Output 3 watts max. Controls. Volume. Tone/On / Off. For use on AC mains 200/250 v.

Price **£3/19/6** plus 2/- P. & P.

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RC4.A (STALLION). This is supplied complete with high flux 8in. P.M. Speaker and Baffle. Incorporating three octal type valves 6Q7, 6V6 and 6X5, this robust and well-made unit is ideal for use in the larger type of record player and is equally suitable for use in conjunction with a radio feeder unit. Separate bass and treble controls are provided: also provision is made for an extension speaker and mains supplies to gram. motor. Output approx. 4 watts. Size overall 13in. × 4in. × 9in. high. For use on A.C. mains 100/200/250 v. Set of 3 engraved knobs in cream or brown **4/-** extra.

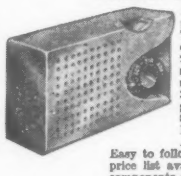
PRICE **£5/19/6** plus 2/6 P. & P. H.P. terms **£2/19/6** deposit and four monthly payments of **16/6**.

Fits our portable cabinet "G" at **85/-** without modification.

VALVES. We have perhaps the most up-to-date valve stocks in the trade. A stamp will bring complete list of brand new imported valve types, fully guaranteed. P.T. paid. Also all usual surplus types available such as 6V6GT, etc.

"R.E.P. MINI-7"

POCKET TRANSISTOR PORTABLE



AT LAST! A pocket-sized SUPERHET Transistor portable for medium and long-wave reception THAT REALLY WORKS, and at a price YOU can afford. The "R.E.P. MINI-7" utilises 2 White Spot, 4 Red Spot and 1 R.F. Transistor specially selected to our specification by leading manufacturer. Push-Pull output. Powered by two 3-volt miniature transistor batteries. Attractive plastic case, finished in dove grey and scarlet. Size only 5½in. × 3¼in. × 1¼in. Incorporates Hi-Grade 2½in. P.M. Loudspeaker, Ferrite Slab Aerial, also drilled and eyeletted Paxolin Chassis.

Easy to follow practical and theoretical diagrams and itemised price list available separately at **1/6** post free. All necessary components at special inclusive price **£10/10/-**. Medium wave only **£9/19/6**, plus 2/6 P. & P.

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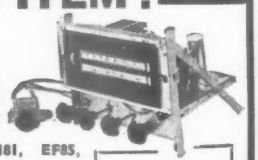
A *NEW*

AM/FM CHASSIS

BY LEADING MANUFACTURER!



★ **Seven valves: ECC85, ECH81, EF85, EABC80, EL84, EZ80, EM81.**

★ **Long, Medium, F.M. Bands and Gram.**

★ **Separate bass and treble controls.**

★ **Illuminated volume control on extended lead.**

★ **Mullard F.M. Tuner Section.**

★ **Attractive dial in Gold on Bronze background (Vertical or Horizontal to choice)**

★ **Fully Guaranteed.**

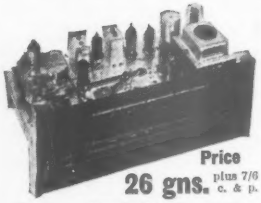
£18'19'6 Plus 5/- P. & P.

This superb chassis is ideal as an up-to-the-minute replacement or as the basis of a new Radiogram. Dimensions (overall) 12in. L. × 10in. .W. × 10in. D. H.P. or Credit Sale Terms Available. Limited Stocks only.

SPECIAL PURCHASE AC/DC CHASSIS MANUFACTURER'S SURPLUS

Owing to favourable purchase we can offer strictly limited quantity of these handsome chassis. AC/DC 200/250 v. for Medium and Long Waves, plus gram position. Incorporates own frame aerial. Valve line up: U107, N108 DH107, W107 and X109. Overall chassis size 12 × 5⅞ × 7½in. high. Attractive bronze dial with gold and cream lettering. Dial size 11½ × 4½in. Scale length 7½in. Logging scale provided. Price **£7/19/6** only, tax paid, plus 3/6 P. & P. H.P. terms. £4 deposit plus four monthly payments of 22/-.

AM/FM CHASSIS



Price 26 gns. plus 7/6 c. & p.

H.P. terms: Deposit **£13/13/-** and 12 months at **£1/3/4**.

THE RC7, FAM. A most attractive AM/FM chassis employing 9 valves with Push-Pull output ● Covers Long, Medium, Short and F.M. wavebands ● Valve line-up: 5Y3, 2-6BW6, 12AU7, EABC80, EF89, ECH81, ECC85 and EM81 ● Built-in Ferrite Rod Aerial for A.M. reception ● Controls: 2 dual, Tuning/Wavechange and Volume ON/OFF/Tone ● 6-8 watts output ● Very attractive easily read dial in BLACK and GOLD ● Size (overall) 15in. × 6in. Chassis dimensions (overall): 15in. × 6in. × 7½in. ● Indoor Aerial for F.M. provided ● For use on A.C. mains 200/250 v. 50 cycles. ● Brand new and fully guaranteed.

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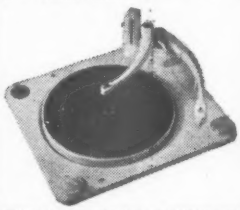
B.S.R. MONARCH. Mixer Autochanger in cream and gold **£7/19/6**, plus P. & P., 3/6. Limited Stocks



THE LATEST COLLARO "CONQUEST" 4-speed autochanger in cream with Studio "O" insert, **£7/19/6**, plus P. & P. 3/6

SINGLE UNITS

COLLARO AC 3/554. Three-speed single player for AC mains 200/250 v. Cream finish, complete with turnover crystal pick-up incorporating the well-known high output "T" type head. Strictly limited quantity at **£5/19/6** plus 3/6 P. & P.

COLLARO 4-SPEED single record unit with separate pick-up and HGP59 crystal cartridge. Brand new, few only, **£4/12/6** plus 3/6 P. & P.

CABINETS TO SUIT ALL TYPES OF EQUIPMENT. Prices from **45/-**. Send stamp for illustrated list.

DULCI

DULCI H.3 AM/FM Chassis (6 valve) Covering Long, Medium and F.M. bands. Most attractive dial in RED and GOLD on BLACK background **£20/17/-** plus 5/- P. & P.

DULCI H.4 PUSH-PULL AM/FM chassis £29/3/10 plus 5/- P. & P.

All Dulci products available ex stock. Illustrated leaflets and H.P. terms available.

Demonstrating at both branches.

MULLARD 510 HIGH FIDELITY AMPLIFIER.

We are proud to be able to offer our printed circuit version of this excellent amplifier, with ULTRA-LINEAR PUSH-PULL output stage, giving an exceptionally high quality output of 10 watts (max.). Built-in Controls are provided for independent bass and treble Tone correction to suit all types of signal input. Will match all crystal or high impedance magnetic pick-up heads, F.M., A.M. or A.M./F.M. tuners or tape recorder output. All required components of best quality to Mullard Spec. are offered at a special inclusive price of **£9/9/- plus 3/6 P. & P.** Instruction Book, containing full constructional details. Theoretical, practical wiring diagrams, itemised price list available separately at **3/6**, post free.

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METER RECTIFIERS 1 m/a. and 5 m/a. each at **6/6**. Brand new.

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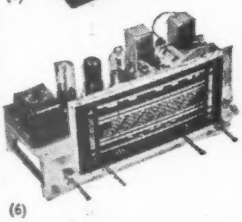

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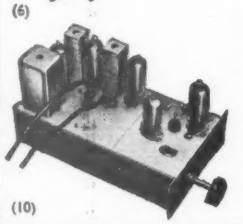

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	All required components at special inclusive price	P.&P.	Instruction Book and itemised price list available separately
(1) New Look " RAMBLER " all dry portable	£7 7 0	2/6	1/6
(2) " RAMBLER " Mains Unit (suitable for most portables)	£2 7 6	1/6	9d.
(3) " ECONOMY FOUR " T.R.F. Mains Receiver	£5 10 0	2/6	1/6
(4) " FAMILY FOUR " (our new T.R.F. Receiver)	£4 19 6	2/6	1/6
(5) " SUPERIOR FOUR " (Four valve mains receiver)	£6 9 6	2/6	1/6
(6) GRAM Chassis 5-valve Superhet	£8 8 0	2/6	1/6
(7) T.S.L. F.M. Tuner (self powered)	£10 19 6	3/6	2/6
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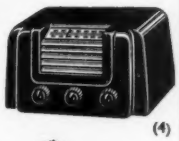
(10) JASON " MERCURY " Switch tuned F.M. feeder	£9 19 6	2/6	2/-
(11) OSRAM 912 Printed circuit F.M. Tuner	£8 8 0	2/6	2/6
(12) JASON " ARGONAUT " AM/FM Chassis	£16 5 0	2/6	2/-
(13) JASON " ARGONAUT " AM/FM Tuner	£13 19 6	3/6	2/-
(14) F.M. Power Pack (suitable for most tuners)	£1 17 6	1/6	1/-
(15) R.C. 3/4 watt amplifier (with Bass, Middle & Treble controls)	£4 5 0	2/6	1/-
(16) 2-amp. Battery Charger	£1 18 6	2/6	3d.
(17) R.C. Transistor/Crystal Receiver (with 'Phones)	£1 17 6	1/3	3d.
(18) R.E.P. 1-valve Battery Receiver " "	£2 2 0	2/-	9d.
(19) " CRY-BABY " ALARM (Baby Alarm) (see below)	£3 12 6	2/6	1/-
(20) " R.E.P. MINI-7 " Transistor Portable (see opp.)	£10 10 0	2/6	1/6
(21) MULLARD 510 Amplifier (Printed circuit) Ultra Linear version	£9 9 0	3/6	3/6
(22) ???			



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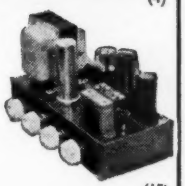

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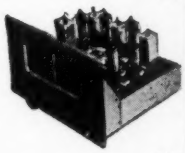

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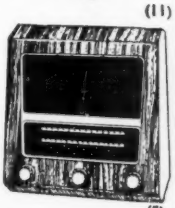


(5)

The following are also available assembled and tested:—
(2) " RAMBLER " Mains Unit, **£3/5/-**; (7) T.S.L. F.M. Tuner, **£13/15/-**; (14) F.M. Power Pack, **52/6**; (15) R.C. 3/4 watt Amplifier, **£5/5/-**; (16) 2-amp. Battery charger, **45/-**; (19) " CRY-BABY " Alarm, **89/6**; Instruction Books which contain full description, easy-to-follow practical wiring diagrams, theoretical diagrams, itemised price lists, etc., are supplied free of charge with all parcels but may be purchased separately if required.
NOTE: (2) The " RAMBLER " Mains Unit is suitable for use with MOST all-dry portables.

No. 38 TRANSMITTER/RECEIVER

(popular Walkie-Talkie). We have been most fortunate in obtaining a further supply of these complete stations comprising TX/RX unit, headphones, microphone, aerial, junction box, battery satchel and full operating instructions. Range: approx. 5 miles. Frequency coverage 7.4-9 mc/s. ABSOLUTELY BRAND NEW, **85/-**.
Export enquiries invited.

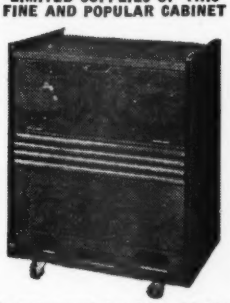
CONSTRUCTOR'S NOTE ! !
RADIO DATA BOOKS AVAILABLE, i.e., Valve guide, Colour code, etc. Send stamp for list.

SPECIAL PURCHASE from MINISTRY BRAND NEW No. 17 Mk. II TRANSMITTER/RECEIVER.

Built into strong wooden cabinet 15in. × 14in. × 9in. Complete with headphones and microphone. Range 5-8 miles with simple aerial. Frequency coverage 44-61 mc/s. (5-7 metres). Uses standard 120 v. H.T. and 2-volt L.T. batteries. Complete with full operating instructions, **59/6**.

N.B.—All our T.R.F. circuits include specially wound Denco "Max Q" coils on polystyrene formers. Osmor High "Q" coils are supplied for our "RAMBLER" Superhet Portable.

LIMITED SUPPLIES OF THIS FINE AND POPULAR CABINET



Instantly recognised as being of leading High Quality manufacturer's stock, this trolley-type cabinet is finished in polished dark walnut. Can easily be adapted to accommodate tape recorder, amplifier, radiogram, etc., etc. External measurements: 24½in. × 16in. × 29in. The whole is mounted upon "easy run" castors. Subject to being unsold **£5/19/6**, plus 15/- C. & P.

THE **CRY-BABY ALARM**

We proudly present this latest addition to our wide range of popular to kits build yourself. **Enjoy your leisure free from anxiety.** This highly efficient unit is simple to assemble, extremely sensitive and may be installed in a matter of minutes. Completely **SAFE** employing a double wound mains transformer. Attractively finished in Red and Grey (washable) "Lionide" with cream plastic escutcheon. Size only 7½in. × 3½in. × 6½in. Supplied in kit form complete with mike at **ONLY 72/6** plus 2/6 P. & P. or assembled and tested **89/6** P. & P. 2/6. Suitable mike flex available at **3d.** a yd. Instruction book and price list available separately 1/- post free. Note: For A.C. mains 200-250 v. only.

BARGAIN CORNER

SPECIAL! A small three valve Portable Record Player Amplifier mounted on baffle 12 × 7in. with High Flux 6½in. Loudspeaker. Valve line-up ECC83, EL84, EZ80. Incorporates separate bass and treble controls. Max. output 3 watts. Will match all types of high impedance pick-up. Ready to use. **£5/12/6** plus 2/6 P. & P.
New style Cabinet finished in two-tone Fawn and Brown Leatherette. Will accommodate above Amplifier and Baffle without modification, also most types of Ancillary Equipment. Overall size: 18 × 13½ × 8½in. Fitted with carrying handle. **£3/9/6** plus 5/- P. & P.
NOTE: If both items purchased together they will be supplied at a special inclusive price of **£8/7/6** plus 6/6 P. & P.

SET OF 10 HI-GRADE TWIST DRILLS. Brand new. All useful sizes from approx. 3/16in. to 1/32in. in cellophane packet **6/-** a set, plus 9d. P. & P. (Ex-W.D.).

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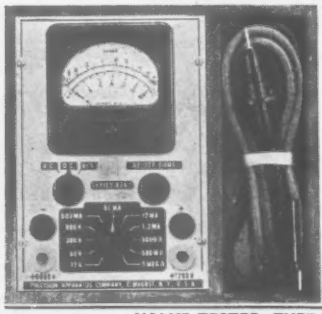
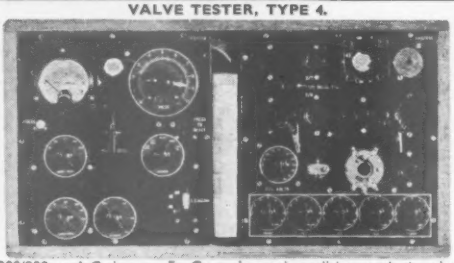


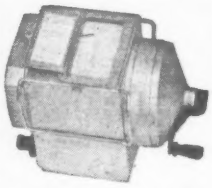
PRECISION SERIES 834-S (U.S.A.). Multi range tester for A.C./D.C. volts, ohms and milliamps. Basic movement 400 micro-amps. Housed in wooden box with lid and carrying strap. Overall size 7½ × 7in. × 5in. Complete with test prods, batteries, etc. Ready to use. **£6/19/6.** Post 2/6.

MARCONI SIGNAL GENERATOR TYPE TF517-F/I. Covering 10–18 Mc/s, 33–58 Mc/s, 150–300 Mc/s. Used but in very good condition. Complete with full technical data and instructions. Limited quantity. Unrepeatable at only **£12/10/-.** Carr. 20/-. ALSO AVAILABLE—ditto—but covering 18–33 Mc/s instead of 10–18 Mc/s band. SAME PRICE.

VALVE TESTER, TYPE 4.



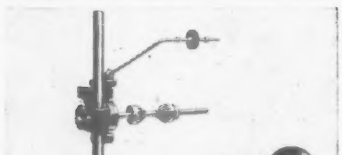
200/230 v A.C. input. Ex Govt., in good condition, with descriptive book containing circuit diagram of instrument and how to test valves from 1.4 v. to 40 v. With valve holders for Brit., 4, 5, 7 pin and Octal, U.S., 5 and 7 pin, I/Octal, side contact large Brit., 4 and 9 pin. Acorn and diode. Housed in substantial wooden case with hinged lid. **£7/19/6.** Carr. 10/-.



EVERSHED & VIGNOLES Series II 500 v. Megger Insulation Tester, with leather carrying case. As new. **£20.** Carr. Paid.

EVERSHED & VIGNOLES MEGGER CIRCUIT TESTER (low reading ohm meter). 2 ranges, 0–3, 0–30 ohms. The perfect meter for continuity and polarity testing. Complete with test leads and ready to use. Brand new. Only **£4/17/6.** P. & P. 3/-.

● **GEE (BROS.) RADIO LTD.** ● *SEE ADVERTISEMENT OPPOSITE*



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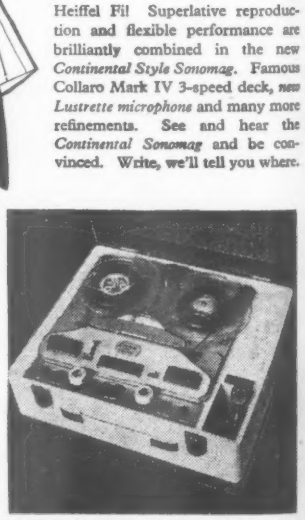

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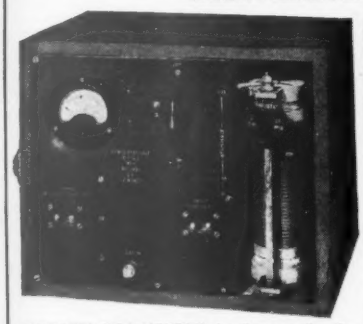
SPECIAL TERMS FOR QUANTITIES—EXPORT ORDERS PROMPTLY EXECUTED



ROTARY CONVERTER (as illustrated). Ex-Govt. 12 v. D.C. input 230 v. A.C. Output 50 cycles at 135 watts. Complete in carrying case with lid, voltage control, sliding resistance, mains switch and 0–300 v. A.C. flush meter. In perfect working order, **£10**, carr. 10/-.

ROTARY CONVERTER. 12 v. D.C. to 230 v. A.C. 50 cycles, 100 watts. Fully tested. **£6/9/6.** Carr. 7/6. Ditto 24 v. D.C. **£4/17/6.** Carr. 7/6.

ROTARY CONVERTER. 110 v. D.C. to 230 v. A.C. 50 cycles, 300 watts. Fully smoothed and suppressed. Housed in strong steel cabinet complete with carrying handles. Absolutely brand new and unused, **£15**. Carr. 10/-.

CONDENSERS. 2 mfd. 7.5 kv. wkg. at 15 kv. test. Good condition. **£2/10/-**, carr. 10/-.

SELENIUM METAL RECTIFIERS.

F/B		F/B	
6 or 12 v. 1 amp.	7/6	24 v. 1 amp. ...	13/6
12 v. 2 amp ...	10/–	24 v. 2 amp ...	20/–
12 v. 2½ amp ...	15/–	24 v. 2½ amp ...	25/–
12 v. 4 amp ...	16/6	24 v. 4 amp ...	30/–
12 v. 6 amp. ...	23/6	24 v. 6 amp ...	35/–
12 v. 10 amp ...	40/–	24 v. 10 amp ...	80/–

AMPLIFIER. 12 v. D.C. For Mobile and Outdoor operation. Powered by Vibrator and Rectifier with 2-EL35's or 6L6's in push pull. Output 18 watts approx., fitted for mike and gram inputs. A sound and practical unit in good condition for only **£12/19/6.** Carr. 5/-. This amplifier if used with our large Re-Entrant Loud Hailer (as illustrated) together with two of our 6 v. 40 AH or 125 AH batteries and a crystal microphone (MIC 35 at 25/-) will make a complete outdoor 12 v. unit ready for use. If all above items are purchased together a 5% discount will be allowed off the total cost.

TRANSMITTER-RECEIVER No. 19. Mk. II complete with 15 valves. Frequency range A set 2-8 meg., B set 230-240 Mc/s., in good condition. **£2/19/6.** Carr. 10/6. 12 V. ROTARY POWER UNIT for above, **£1.** Carr. 5/-. All leads, headsets, variometers, etc., available.

CATHODE RAY TUBES. VCR139A 2¾in., **30/-**; 3BP1, 3in., **30/-**; 5FP7, 5in., **35/-**; VCR97, 6in., **20/-**; all new and unused. P. & P. 3/- each.

18/24 v. 10 AMP. BATTERY CHARGERS for 200-250 v. 50 cycles input, metered, switched and fused. As new, **£12/10/-**. Carr. 20/-.

A.C.-D.C. RECTIFIER POWER SUPPLY UNIT. 230 v. A.C. 50 cycles input. 100 v. D.C. output max. 2½ amp. **£4/10/-**. Carr. 7/6.

C.M.G. 25 PHOTO CELLS (OSRAM). Brand new. 15/-. P. & P. 1/-.

RE-ENTRANT LOUD HAILERS (Ex-Govt.)

Heavy duty 20 watts all-metal 15 ohms. Diameter 15in., length 15in. (approx.). Perfect condition. **£6/10/-**. Carr. 10/-.

TRANSFORMERS

RCA PLATE TRANSFORMERS. .190 to 250 v. primary. 50–60 cycles. Secondary 1,500–0–1,500 or 2,000–0–2,000, at 1.75 kVA. Brand new and boxed. **£12/10/-**. Carr. 10/-.

VARIAC TRANSFORMER. 230 v. 50 cycles input, controlling 0–230 v. continuously at 9 amps. Perfect order. **£12/10/-**. Carr. 10/-.

DITTO, smaller type. 0–250 v. input controlling from 200–230 v. at 7 amps. **92/6** Carr. 5/-.

200 WATT AUTO-TRANSFORMER. 230–115 v. Fully shrouded, new and unused. **24/6.** P. & P. 2/6.

L.T. TRANSFORMERS. Pri. 200–250 v. 50 cycles A.C., Sec. 17.5 v. at 35 amps. **£4/15/-**. Carr. 10/-.

TRANSFORMER (FERRANTI). Potted for 0–250 v. 50 cycles tapped primary, sec. 1,250 v., 15 mA. Ideal for oscilloscopes, etc. Size 3⅛×3⅛×4⅛in. ONLY **35/-**. P. & P. 2/6.

E.H.T. TRANSFORMERS. 3,850 v. at 50 mA. with two additional 4 v. L.T. windings for 230 v. 50 cycles primary. New and boxed. **£3/15/-**. Carr. 5/-.

VARIABLE VOLTAGE REGULATOR TRANSFORMERS. Input 230 v. A.C. at 21 amps. Output 57.5 volts in 16 equal steps to 230 v. at 21 amps. Ex-Govt., in perfect condition. **£12/10/-**. Carr. 15/-.

TRANSFORMERS. 110–230 v. Pri. Sec. 26 v. tapped to 41 v. at 14 amps. New and boxed. **£3/10/-**. Carr. 5/-.

CAR RADIO VIB. TRANSFORMERS. 6 v. Input 280 v. at 80 mA. H.T. (ex-Philco). New, in perfect condition. **12/6.** P. & P. 2/-. Ditto 12 v., same price.

E.H.T. TRANSFORMER. 20 kV. at 140 mA. 230 v. 50 cycles primary. New and unused. Ex-Govt. Built to the highest specification. **£22.** Carr. 30/-.

TRANSFORMER. 1,800–0–1,800 at 1 kVA. 230 v. 50 cycles primary. Fully tropicalised. New and boxed. **£8/15/-**. Carr. 10/-.

MINIATURE 373 I.F. STRIPS for F.M. tuner as described in "Practical Wireless." Complete with all valves, conversion instructions and circuit. BRAND NEW. ONLY **42/6**, post paid.

TELEPHONE CABLE (Don 8). Twin one mile drums. **£5.** Carr. 20/-.

H.R.O. COILS. Frequency 50–100 kc/s. NEW. ONLY **15/-**.

RECORDING WIRE. ¼ lb. spools, 3½in. dia. New and unused, **9/-**. P. & P 1/-.

MORE BARGAINS IN TEST EQUIPMENT

METERS. 0–1 mA. 2in. circular F/M, **17/6.** Ditto 2½in., **25/-**. 0–50 microamps. D.C. m/c., projecting 2½in. round, **49/6.** 0–10 m/A. A.C. m/c., rectifiers, F/M 3½in., round **49/6.** 0–300 v. A.C. 2½in. F/M, **25/-**. 0–200 v. A.C. 3½in. F/M. **25/-**. 0–300 v. A.C. 3½in. F/M, **25/-** each.

RECORD MEGGERS. 500 v. insulation tester, 0–50 megohms. In leather case, good condition. **£8.**

TEST SET TS-26/TSM. This volt ohmmeter is the correct tester for EE8 telephones and all standard telephone equipment. Brand new and boxed, with full technical data and calibration charts. **£7/10/-**.

EVERSHED AND VIGNOLES WEE MEGGER 500 v. New and unused. Only **£12/10/-**. Ditto 250 v. **£19/10/-**. P. & P. 3/- on each.

AVO TEST BRIDGE. A.C. mains operated from 200–250 v. Will test resistance from 5 ohms to 50 megohms and capacity from .00001 to 50 mfds. A most useful instrument for everyday uses. Our price ONLY **£7/19/6.** P. & P. 3/6.

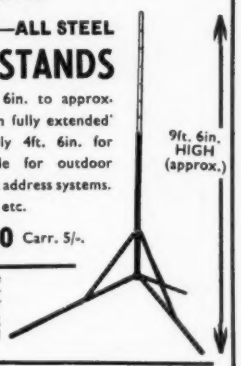
HEAVY DUTY—ALL STEEL

TRIPOD STANDS

Adjustable every 6in. to approx. 9ft. 6in. high when fully extended (Folds up to only 4ft. 6in. for storage). Suitable for outdoor speakers for public address systems. floodlighting, etc., etc.

OUR PRICE **£3.10.0** Carr. 5/-.

These stands are ideal for our RE-ENTRANT LOUD HAILER as described below.



BAKERS SELHURST

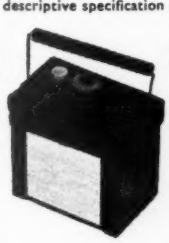
★ SPEAKERS ★

12in. P.M. 15 ohms 15 watts, 30–14,000 c.p.s. **£4/10/-**.

"HI-FI MASTER" 12in., 15 ohms, 12 watts, 20–16,000 c.p.s. Flux density approx. 14–15,000. OUR PRICE **£7/10/-**.

"SUPER HI-FI 25," 12in., 15 ohms, 25 watts, 25–20,000 c.p.s. Flux density 17,600. OUR PRICE **£9/9/-**.

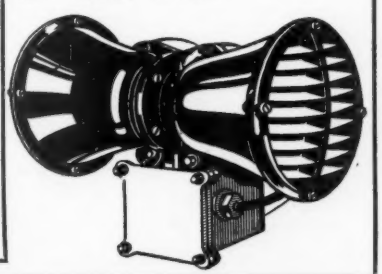
All the above speakers are Brand New and full descriptive specification is available.



ACCUMULATORS. Bakelite cased 2 v. 100 ampere 75 actual. Ex-Govt. New and unused. Complete with carrying handle. Size 6½ × 6½ in. × 3½in. **15/-** each. Carr. 3/6. 3 sent for **50/-** or 6 for **£5** carr. paid. Ditto, 14 A.H. less handle **5/6.** P. & P. 2/-.

6 V. 20 A.H. ACCUMULATORS comprising three 2 v. celluloid-cased cells in wooden case. Size 5 × 5 × 7½in. New and unused. **17/6.** P. & P. 3/6.

PARMEKO TWIN BAKELITE LOUD HAILERS (ex-Admiralty). Mounted on metal base. Complete with 600 ohm line transformer. 15 ohm voice-coil. Ideal for P.A. and all outside work. Length 15in., height 9in., dia. of horns 8½in. Price **45/-**. Carr. 7/6.



SELENIUM RECTIFIERS

L.T. Types

2/6 v. ½ a.h.w.	1/9
6/12 v. ½ a.h.w.	2/9
F.W. Bridge	
6/12 v. 1 a. ..	4/11
6/12 v. 2 a. ..	9/9
6/12 v. 3 a. ..	11/9
6/12 v. 4 a. ..	14/9
6/12 v. 6 a. ..	19/9
6/12 v. 10 a. ..	25/9
H.T. Type H.W.	
120 v. 40 mA.	3/9
250 v. 50 mA.	5/9
250 v. 80 mA.	7/9
350 v. 60 mA.	7/9
250 v. 250 mA.	10/9

BATTERY CHARGING EQUIPMENT

All for A.C. Mains 200-250v., 50 c/s. Guaranteed 12 months

ASSEMBLED CHARGERS

6 v. 1 a.	19/9
6/12 v. 1 a.	27/9
6 v. 2 a.	29/9
6/12 v. 2 a.	38/9
6/12 v. 4 a.	56/9

Above ready for use with mains and output leads. Cases well ventilated and finished in stoved blue hammer. Carr. and packing 3/6.

BATTERY CHARGER KITS

Consisting of Mains Transformer F.W. Bridge. Metal Rectifier, well ventilated steel case. Fuses, Fuse-holders, Grommets, panels and circuit. Carr. 2/6 extra.

6 v. or 12 v. 1 amp. ..	22/9
6 v. 2 amps.	25/9
6 v. or 12 v. 2 amps. ..	31/6
6 v. or 12 v. 4 amps. ..	53/9

BATTERY CHARGER KIT Consisting of F.W. Bridge Rectifier 6/12 v. 5 a. Mains Trans. 0-9-15 v. 6 a. output, and ammeter. Only 49/9. Post 3/-.

ASSEMBLED CHARGER

6 v. or 12 v. 2 amps.

Fitted Ammeter and selector plug for 6 v. or 12 v. Louvred metal case, finished attractive hammer blue. Ready for use with mains and output leads. Double Fused. Only **49/9** Carr. 3/6.

Assembled 6v. or 12v. 4 amps.

Fitted Ammeter and variable charge selector. Also selector plug for 6 v. or 12 v. charging. Double fused. Well ventilated steel case with blue hammer finish. Ready for use with mains and output leads. Carr. 3/9. Or 30/- Deposit and four monthly payments **13/-**

SEND FOR LEAFLET OF EASY TO ASSEMBLE CABINETS FOR HI-FI EQUIPMENT AVAILABLE CASH OR CREDIT

AM/FM RADIOGRAM CHASSIS, HIGH QUALITY. PUSH PULL. 6-8 WATTS OUTPUT

Current manufacture. 12 months' guarantee. For 200-250 v. mains. Covers L and M. Wavebands plus F.M. Includes 8 latest type miniature B.V.A. valves. Only 22 **gns.** plus 7/6 carr. Or deposit £2/12/- and 9 monthly payments of £2/12/-. Guaranteed 12 months.

AM/FM RADIOGRAM

29½ GNS.

By leading manufacturer. Brand new, cartoned, 4 wavebands including V.H.F. Auto-changer at 3 speeds, Hi-Fi pick-up with duo point sapphire stylus. For 200-250 v. 50 c.p.s. A.C. mains. Limited stocks at a fraction of listed price. Only 29½ **gns.** Or Deposit £6/19/6 and 9 monthly payments of 3 **gns.** Carr. 10/-.

THE SKY FOUR T.R.F. RECEIVER

A design of a 3 valve 200-250 v. A.C. Mains L. & M. wave T.R.F. receiver with selenium rectifier. For inclusion in cabinet illustrated or walnut veneered type. It employs valves 6K7, SP61, 6F6G, and is specially designed for simplicity in wiring. Sensitivity and quality is well up to standard. Point-to-point wiring diagrams, instructions and parts list, 1/9. This receiver can be built for a maximum of £4/19/6 including cabinet. Available in brown or cream bakelite, or veneered walnut.

R.T.C. 12in. "SUPER HI-FI 25" LOUDSPEAKER UNIT

With mechanical damping device. A 25 watt 15 ohm precision built moving coil unit with 17,600 line Alcomax magnet. Frequency range 25–20,000 c.p.s. Designed to provide lifelike reproduction In large halls, theatres, cinemas, etc. Only 12 **gns.** Or Deposit 28/9 and 9 monthly payments 28/9.

LINEAR HIGH FIDELITY 3-SPEAKER SYSTEM

Consists of matched 12in., 8in. and 5in. speakers with cross-over network and frequency discriminator. Frequency range 30–20,000 c.p.s. Suitable for considerably improving the quality of output from a domestic radio receiver or for realistic handling of sound output from a high fidelity amplifier rated at up to 12 watts. The speakers etc. are mounted on an attractive, walnut veneered baffle size approx. 36 × 32 × 10in. Only 19 **gns.** or Deposit 6 **gns.** and 9 monthly payments of 35/-. Send S.A.E. for illustrated leaflet. The system is also available without matched baffle. Price is 10 **gns.** plus 7/6 carr. Or Deposit 25/6 and 9 monthly payments of 25/6.

COLLARO RC54 3 SPEED MIXER AUTO-CHANGER

Fitted Studio Pick-up with turnover head. Brand new cartoned but for 110 v. 50 c.p.s. A.C. mains. So that the unit can be operated from normal 200-250 v. A.C. mains we are supplying free with every changer a suitable auto transformer with input and output voltages clearly marked. Limited number only. £6/19/6. Carr. 5/6.

COLLARO 4-SPEED AUTO-CHANGERS

With studio pick-up with turnover head, BRAND NEW. Cartoned, latest model. For 200-250 v. A.C. mains. Very limited number Conquest £8/19/6. Continental 9 **gns.** Carr. 5/6.

R.S.C. BATTERY TO MAINS CONVERSION UNITS

Type BM1. An all dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.4 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. **Suitable for all battery portable receivers requiring 1.4 v. and 90 v.** This includes latest low consumption types. Complete kit with diagram. 39/9 or ready for use 46/9.

Type BM2. Size 8 × 5½ × 2½in. Supplies 120 v., 90 v., and 60 v., 40 mA. and 2 v. 0.4 a. to 1 amp. fully smoothed **THEREBY COMPLETELY REPLACING BOTH H.T. BATTERIES AND L.T. 2 v. ACCUMULATORS** when connected to A.C. mains supply 200-250 v. 50 c/s. SUITABLE FOR ALL BATTERY RECEIVERS normally using 2 v. accumulator. Complete kit with diagrams and instructions, 49/9, or ready for use, 59/6.

R.S.C. TRANSFORMERS

FULLY GUARANTEED. INTERLEAVED AND IMPREGNATED

MAINS TRANSFORMERS

Primaries 200-230-250 v. 50 c/s.

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250 v. 60 mA., 6.3 v. 2 a., 5 v. 2 a.	17/6
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
250-0-250 v. 100 mA., 6.3 v. 6 a., 5 v. 3 a., for R1355 conversion	31/-
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	25/9
300-0-300 v. 130 mA., 6.3 v. 4 a., c.t., 6.3 v. 1 a., suitable for Mullard 510 Amplifier	33/9
375-0-375 v. 150 mA., 6.3 v. 4 a., 5 v. 2 a.	29/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	33/9
350-0-350 v. 150 mA., 6.3 v. 2 a., 6.3 v. 2 a., 5 v. 3 a.	33/9
425-0-425 v. 200 mA., 6.3 v. 4 a., c.t., 6.3 v. 4 a., c.t., 5 v. 3 a., suitable Williamson Amplifier, etc.	49/9

TOP SHROUDED DROP-THROUGH TYPE

260-0-260 v. 70 mA., 6.3 v. 2 a., 5 v., 2 a.	16/9
350-0-350 v. 80 mA., 6.3 v. 2 a., 5 v. 2 a.	18/9
250-0-250 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	22/9
300-0-300 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 100 mA., 6.3 v. 4 a., 5 v. 3 a.	23/9
350-0-350 v. 150 mA., 6.3 v. 4 a., 5 v. 3 a.	29/9

ELIMINATOR TRANSFORMERS

Primaries 200-250 v. 50 c/s.

120 v. 40 mA., 5-0-5 v. 1 a.	14/9
90 v. 15 mA., 6-0-6 v. 250 mA.	9/11

FILAMENT TRANSFORMERS

Primaries 200-250 v. 50 c/s.

6.3 v. 1.5 a.	5/9	6.3 v. 3 a.	8/11
6.3 v. 2 a.	7/6	6.3 v. 6 a.	17/6
0-4-6.3 v. 2 a. ..	7/9	12 v. 3 a. or	
12 v. 1 a.	7/9	25 v. 1.5 a. ..	17/6

CHARGER TRANSFORMERS

All with 200-230-250 v. 50 c/s. Primaries: 0-9-15 v. 1½ a., 11/9; 0-9-15 v. 3 a., 16/9; 0-9-15 v. 5 a., 19/9; 0-9-15 v. 6 a., 23/9.

OUTPUT TRANSFORMERS

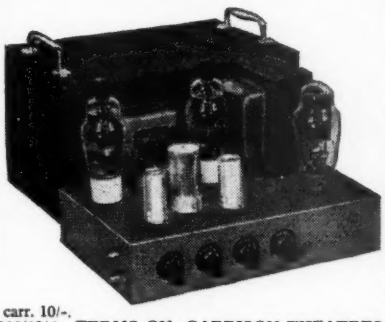
Midget Battery Pentode 66:1 for 3S4, etc.	3/6
Small Pentode 5,000Ω to 3 Ω.....	3/9
Standard Pentode, 5,000 Ω to 3 Ω	4/6
Standard Pentode, 8,000 Ω to 3 Ω	4/9
Push-pull 8 watts 6V6 to 5 ohms	8/9
Push-pull 10-12 watts 6V6 to 3 Ω or 15 Ω	15/9
Push-pull 10-12 watts to match 6V6 to 3-5-8 or 15 Ω	16/9
Push-pull EL84 to 3 or 15 ohms	16/9
Push-pull 15-18 watts, sectionally wound, 6L6, KT66, etc., to 3 or 15 ohms	21/9
Push-pull 20 watt high-quality sectionally wound, 6L6, KT66, etc. to 3 or 15 Ω	47/9

SMOOTHING CHOKES

250 mA., 5 H., 100 ohms	11/9
150 mA., 7-10 H., 250 ohms	11/9
100 mA., 10 H., 200 ohms	8/9
80 mA., 10 H., 350 ohms	5/6
60 mA., 10 H., 400 ohms	4/11
1 amp. 0.5 ohm. L.T. type	6/6

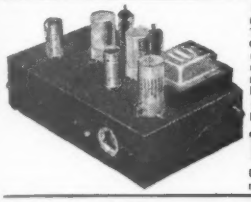
R.S.C. A10 ULTRA LINEAR 30 WATT AMPLIFIER

HIGH FIDELITY PUSH-PULL UNIT EMPLOYING SIX VALVES. EF86, EF86, ECC83 807, 807, GZ34. Tone Control Pre-amp stages are incorporated. Sensitivity is extremely high. Only 12 millivolts minimum input is required for full output. **THIS ENSURES THE SUITABILITY OF ANY TYPE OR MAKE OF MICROPHONE OR PICK-UP.** Separate Bass and Treble controls give both "lift" and "cut" with ample tone correction for long playing records. An extra input with associated vol. control is provided so that two separate inputs such as "mike" and gram., etc., etc., can be simultaneously applied for mixing purposes. **AN OUTPUT SOCKET WITH PLUG IS INCLUDED FOR SUPPLY OF 300 v. 20 mA. and 6.3 v. 1.5 a. FOR A RADIO FEEDER UNIT.** Price in kit form with easy-to-follow wiring diagrams.
Cover as illustrated 18/9 extra. Only **11 Gns.** carr. 10/-.
Or Factory built with 12 months' guarantee **£13/19/6.** TERMS ON ASSEMBLED UNITS. DEPOSIT 36/9 and 9 monthly payments of 31/9.



Type 807 output valves are used with High Quality Sectionally wound output transformer specially designed for Ultra Linear operation. Negative feedback of 20 D.B. in main loop. **CERTIFIED PERFORMANCE FIGURES ARE EQUAL TO MOST EXPENSIVE UNITS AVAILABLE.** Frequency response ± 3 D.B., 30-20,000 c/s., Tone Controls ± 12 D.B. at 50 c/cs., + 12 D.B. to − 6 D.B. at 12,000 c/cs., Hum and noise 70 D.B. down. Good quality reliable components used. Chassis finish blue hammer. Overall size 12 × 9 × 9in. approx. Power consumption 150 watts. For A.C. mains 200-230-250 v. 50 c/cs. Outputs for 3 and 15 ohm speakers. **EQUALLY SUITABLE FOR THE CONNOISSEUR OR FOR LARGE HALLS, CLUBS, or OUTSIDE FUNCTIONS. IDEAL FOR USE WITH MUSICAL INSTRUMENTS SUCH AS STRING BASS, ELECTRONIC ORGAN, GUITAR, etc. FOR DANCE BANDS,** etc. We can supply Microphones, Speakers, etc., at keen cash prices or on terms with amplifiers.

EXPORT ENQUIRIES INVITED

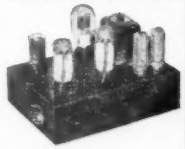


LINEAR LT/45 HIGH QUALITY TAPE DECK AMPLIFIER
COMPLETE with POWER PACK and OSC. STAGE. Suitable for Collaro Lane, Truvox, Aspden, Brennell, etc., etc. State make of Deck when ordering'. Chassis size 12-7-3in Overall size 12-7-6½in. For 200-250 v. 50 c/cs. A.C. mains. Output for standard 2-3 ohm speaker. Only 15 millivolts input required for full recording. Only 2 millivolts minimum output required from recording head. Magic Eye recording level indicator. Provision for feeding P.A. amplifier. Negative feed-back equalisation. Linear frequency response ± 3 D.B. 50-11,000 c/cs. Facilities for recordings at 15in., 7½in. or 3¾in. per second. Automatic equalisation at the turn of a knob. When switching from record to playback position automatic demagnetisation of heads is assured. Separate gain and output controls. Valves type ECC83, ECC83, EL84, EZ80, EM34. Output 4 watts. Unit supplied with maker's 12 months' guarantee. We know of no other make which represents the same exceptional value. Leaflet 6d.
12 Ready for use **GNS.** Carr. 7/6.

COLLARO JUNIOR 4 SPEED RECORD PLAYER with separate pick-up having dual point sapphire stylus. Brand new, cartoned. For 200-250 v. A.C. mains only Only **4 GNS.** Post 3/6.

LG3 MINIATURE 3 WATT GRAM. AMPLIFIER
For 200-250 v. 50 c.p.s. A.C. Mains. Overall size only 6¼ × 4¼ × 2¾in. Fitted vol. and Tone Control with mains switch. Designed for use with any kind of single player or record changing unit. Output for 2-3 ohms speaker. Guaranteed 12 months. Only **55/9**

R.S.C. A5 4-5 WATT HIGH GAIN AMPLIFIER



A highly sensitive 4-valve quality amplifier for the home, small club, etc. Only 50 millivolts input is required for full output so that it is suitable for use with the latest high-fidelity pick-up heads in addition to all other types of pick-ups and practically all mikes. Separate Bass and Treble controls are provided. These give full long playing record equalisation. Hum level is negligible being 71 D.B. down. 15 D.B of negative feedback is used. H.T. of 300 v. 26 mA. and L.T. of 6.3 v. 1.5 a. is available for the supply of a Radio Feeder Unit or Tape Deck pre-amplifier. For A.C. mains input of 200-230-250 v. 50 c/s. Output for 2-3 ohm speaker. Chassis is not alive, Kit is complete in every detail and includes fully punched chassis (with baseplate) with the blue hammer finish, and point-to-point wiring diagrams and instructions. Exceptional v..lue at only **£4/15/-**, or assembled ready for use **25/-** extra, plus 3/6 carriage. Or Deposit **22/-** and five monthly payments of **22/-** for assembled unit.

R.S.C. A7 3-4 WATT QUALITY AMPLIFIER
A highly sensitive 4-valve amplifier using negative feedback and having an excellent frequency response. Pre-amplifier and Tone Control stages are incorporated with separate Bass and Treble controls giving full tone compensation for long playing records. Suitable for any kind of pick-up including latest high fidelity types. H.T. of 250 v. 20 mA and L.T. 6.3 v. 1 a., available for supply of Radio Feeder Units, etc. ONLY 40 millivolts input required for full output. Fully isolated chassis with baseplate. For A.C. mains 200-250 v. 50 cycles. Output for 2-3 ohm speaker. Complete kit of parts point-to-point wiring diagrams and instructions. Only **£3/15/-**, carr. 3/6 or factory built **25/-** extra.

SENSATIONAL OFFER
STAAR GALAXY 4-SPEED MIXER AUTO-CHANGERS
A precision manufactured unit with unique finger tip control. Pick-up fitted with dual sapphire tipped stylus. A very compact changer in attractive duo-tone finish. For A.C. mains 110—250v. Brand new, cartoned. **£4/19/6.** *Post 4/6.*

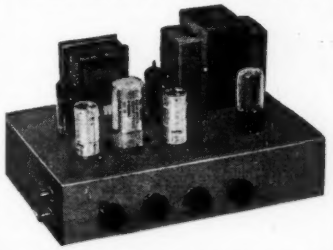
ACOS HIGH FIDELITY PICK-UPS. GP54 with HGP59/52 cartridge. Dual point sapphire stylus. Cream finish. A fortunate purchase enables us to offer these at approx. half price. Only **29/11**

LINEAR "DIATONIC" 10-WATT HIGH FIDELITY AMPLIFIER. Incorporating pre-amp. For A.C. mains input 200-230-250 v. 50 c.p.s. A compact attractively finished unit with two separately controlled inputs and outputs for 3 and 15 ohms speakers. Separate Bass and Treble controls. Five latest type miniature Mullard valves. Only **12 Gns.** Send S.A.E. for leaflet and credit terms.

LINEAR L45 MINIATURE 4/5 W. QUALITY AMPLIFIER. Suitable for use with Garrard B.S.R. or any other record playing unit and most microphones. Total negative feedback 12 D.B. Separate Bass and Treble controls. For A.C. mains input of 200-250 v. 50 c.p.s. Output for 2/3 ohm speaker. Three miniature Mullard valves used. Size only 6 × 5 × 5¼in. high. Chassis fully isolated from mains. Guaranteed 12 months. Only **£5/19/6.** Or Deposit **22/-**, and five monthly payments of **22/-**. Send S.A.E. for leaflet.

PLESSEY DUAL CONCENTRIC 12in. P.M. SPEAKERS
(15 ohms), consisting of a high quality 12in. speaker of orthodox design supporting a small elliptical speaker ready wired with choke and condensers to act as tweeter. This high fidelity unit is highly recommended for use with our A11 or any similar amplifier. Rating is 10 watts. Gauss 12,000 lines. Price only **£5/17/6.** Or Deposit **13/-** and nine monthly payments of **13/-**.

All ULTRA LINEAR 12-14 WATT AMPLIFIER



NEW 1958 DESIGN HIGH-FIDELITY PUSH-PULL AMPLIFIER WITH "BUILT-IN" TONE CONTROL PRE-AMP. STAGES

Two input sockets with associated controls allow mixing of "mike" and gram. as in A10. High sensitivity. Includes 5 valves, ECC83, ECC83, EL84, EL84, 5Y3. High Quality sectionally wound output transformer specially designed for Ultra Linear operation, and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut" Frequency response ±3 DB 30-30,000 c/cs. Six negative feedback loops. Hum level 60 DB down ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs. For **STANDARD or LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, GUITARS** etc., **OUTPUT SOCKET** with plug provides 300 v. 30 m.a. and 6.3 v. 1.5 a. For supply of a **RADIO FEEDER UNIT.** Size approx. 12-9-7in. For A.C. mains 200-230-250 v. 50 c/cs. Output for 3 and 15 ohms speakers. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagrams supplied.

Only **8 GNS.** or factory built **45/-** extra. Carr. 10/-. If required louvred metal cover with 2 carrying handles can be supplied for **18/9. TERMS ON ASSEMBLED UNITS. DEPOSIT 25/6 and nine monthly payments of 25/6.** Send S.A.E. for Illustrated leaflet detailing. Ready-to-assemble Cabinets, Speakers, Microphones, etc., with cash and credit terms.

W.B. "STENTORIAN" HIGH FIDELITY P.M. SPEAKERS.
HF1012, 10 watts 15 ohm (or 3 ohm) speech coil. Where a really good quality speaker at a low price is required, we highly recommend this unit with an amazing performance. **£4/10/9.** Please state whether 3 ohm or 15 ohm required.

P.M. SPEAKERS. 2-3 ohm 2½in. Rola **17/9.** 5in. Goodmans **17/9.** 7 × 4in. Elliptical **19/9.** 6½in. Rola, **19/9.** 8in. Rola, **19/9.** 8in. Goodmans **21/9.** 10in. R.A., **28/9.** 10 × 6in. Elliptical Goodmans **29/9.** 12in. Plessey **29/11.** 12in. Plessey 3 ohms, 10 watts, 12,000 lines, **59/6.**

SUPERHET RADIO FEEDER UNIT
Design of a high quality Radio Tuner Unit (specially suitable for use with any of our Amplifiers). A Triode Heptode F/changer is used. Pentode I.F. and double Diode Second Detector, delayed A.V.C. is arranged so that A.V.C. distortion is avoided. The W.Ch. 8w. incorporates Gram. position. Controls are Tuning, W. Ch. and Vol. Output will load most Amplifiers requiring 500 mV input depending on Ae location. Only 250 v. 15 mA. H.T. and L.T. of 6.3 v. 1 amp. required from amplifier. Size of unit approx. 9-6-7in. high. Send S.A.E. for illustrated leaflet. Total building cost is **£4/15/-**. Point-to-point wiring diagrams and instructions, **2/6.**

Radio Supply Co. (LEEDS) LTD.

Personal Shoppers to **MAUDE ST.** (Opposite Parish Church School) **LEEDS, 2.**
Mail Orders to **29-31, Moorfield Road, LEEDS, 12.**

Terms: C.W.O. or C.O.D. No C.O.D. under £1. Postage 1/9 extra on all orders under £2. 2/9 extra under £5 unless carriage charge stated. Full Price List 6d. Trade List 5d. Open to Callers: 9 a.m. to 5.30 p.m. Saturday until 1 p.m. S.A.E. please with all enquiries.

RADIO SUPPLY CO. (LEEDS) LTD.

(Dept. D) Maude Street, (Opposite Parish Church School) Leeds, 2.

FOR TERMS SEE DISPLAYED ADVERT PAGE 129

CO-AXIAL CABLE. 75 ohms, ½in., 8d. yard. Twin screened feeder 11d. yard.

ELECTROLYTICS (current production) Not Ex-Govt.

Tubular Types		Can Types	
8 mfd. 450 v.	1/9	16μF 450 v.	2/9
8 mfd. 500 v.	2/6	32μF 350 v.	2/11
16μF 350 v.	1/11	32 mfd. 450 v.	4/9
16μF 450 v.	2/9	100 mfd. 450 v.	4/9
16μF 500 v.	3/9	8-8μF 450 v.	2/11
25μF 25 v.	1/3	8-16μF 450 v.	3/11
50μF 12 v.	1/3	16-16μF 450 v.	3/11
50 mfd. 25 v.	1/9	32-32μF 350 v.	4/9
50μF 50 v.	1/9	32-32μF 450 v.	5/9
100 mfd. 12 v.	1/9	100-100 mfd. 350 v.	5/9
100 mfd. 25 v.	2/3	150 mfd. 450 v.	5/9
3,000 mfd. 6 v.	3/9	100-200 mfd. 275 v.	6/11
6,000 mfd. 6 v.	3/11		

VOLUME CONTROLS with long spindles, all values, less switch, 2/9; with S.P. switch, 3/9.

EX GOVT. STEP UP/STEP DOWN TRANSFORMERS. Double wound 80/100 watts. 10-0-100-200-220-240 v. to 5-0-75-115-125-135 v. or Reverse. Only 12/9 plus 2/9 post 10-0-100-200-220-240 v. to 9-0-110-122-136-148 v. or Reverse. 300 watts, 35/9, plus 7/6 carr.

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4 mfd. 1,000 v. 3/9 8 mfd. 500 v. 4/6
10 mfd. 500 v. 3/9

EX GOVT. VIBRATOR UNITS. 12 v. input, 280 v. output. Suitable for Car Radio, etc. 16/6.

VIBRATORS, oak and Wearite, synchronous 7 pin, 2 v. 7/9, 6 v. 8/9.

JUNCTION TRANSISTORS. R.F. type 17/6, A.F. 7/9.

INSTRUMENT KNOBS. Black 1¼in. diam. Standard type 1/- each. 9/- doz. 90/- gross.

BAKELITE FUSE HOLDERS. Panel mtg. 4/6 doz.

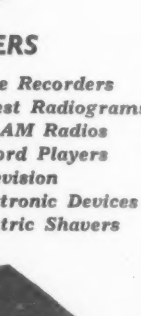
LINEAR 50 WATT HIGH FIDELITY AMPLIFIER Sensitivity 25 millivolts for full output. Completely enclosed in well ventilated case with carrying handles. Suitable for any kind of Microphone or pick-up. Output matchings for 3 ohm and 15 ohm speakers. Brand New, cartoned. Guaranteed 12 months. For 200-250 v. 50 c.p.s. A.C. mains. Only 19 gns. Carr. 15/- . Or Dep. 3 gns. and 9 monthly payments of 42/3.

EX. GOVT. 50 WATT AMPLIFIERS. Brand new. For 200-250 v. 50 c.p.s. A.C. mains. Designed for speech only but with suitable pre-amp, could be used with Gram. or Radio. Valves included. Four 6L6s used for output. Complete with hand microphone with good length of lead. Unused in original transit cases. Only 9 gns. Ready for use. Carr. 15/-.

RE-ENTRANT SPEAKERS. Tannoy 8 watt, 7,5 ohms suitable for above, 25/- each.

5 CORED FLEX. Rubber insulated, individually coloured 14/36. 1/3 yard, 50/- 50 yards. £4 per 100 yards.

EX GOVT. MAINS TRANSFORMERS
All 200-250 v. 50 c/s. input.
250-0-250 v. 60 mA., 6.3 v. 3 a., 6.3 v. 1 a. Potted 4½-3½-3in. 11/9
Pr. 0-110-200-230-250 v., 275-0-275 v. 100 mA., 6.3 v. 7 a., 5 v. 3 a. 21/9
230-0-230 v. 80 mA., 12.6 v. 1.5 a. 5 v. 2 a. 11/9
250-0-250 v. 150 mA. 5 v. 3 a. 16/9
350-0-350 v. 160 mA. 6.3 v. 5 a., 5 v. 3 a. 27/9
400-0-400 v. 250 mA. 5 v. 2 a., 5 v. 2 a. 18/9
450-0-450 v. 150 mA. 6.3 v. 5 a., 6.3 v. 1 a., 5 v. 3 a. 29/9
450-0-450 v. 250 mA. 6.3 v. 3 a., 6.3 v. 1 a., 5 v. 6 a. 49/9
12.5 v. 3 a., 5 v. 3 a. 12/9
0-24-26-28 v. 15 amp. A.C. conservative Gov. rating (marked with D.C. rating after rectification) 69/9. Carr. 10/-.
0-10-20-25 v. 24 a. (Gov. rating) 79/6. Carr. 15/-.



EXTENSION SPEAKERS Limited number in handsome Walnut veneered cabinets. 2-3 ohm speech coils. 6½in. 29/9. 8in. 35/9.

MANUFACTURERS' SURPLUS TRANSFORMERS. Primary 230-250 v. Drop through type 325-0-325 v. 100 mA., 6.3 v. 2.5 a., 5 v. 2 a. 17/9. Post 2/9.

EX GOVT. SMOOTHING CHOKES
250 mA., 20 H., 150 ohms 19/6
250 mA., 5 H., 50 ohms 12/9
150 mA., 10 H., 50 ohms 10/11
120 mA., 12 H., 100 ohms 9/9
100 mA., 10 H., 100 ohms 6/9
100 mA., 5 H., 100 ohms, tropicalised 3/11
80 mA., 20 H., 900 ohms 6/9

EX. GOVT. CASES. Well ventilated, black crackle finished, undrilled cover. Size 14×10×8½in. high. IDEAL FOR BATTERY CHARGER OR INSTRUMENT CASE, COVER COULD BE USED FOR AMPLIFIER. Only 9/9, plus 2/9 post. Size 13½in. × 8in. × 6½in. with undrilled perforated cover finished in stoved grey enamel, 9/9, plus 2/9 post.
SPECIAL OFFERS. Small 2 gangs .0005 mfd., 4/9. Electrolytics 32-32-32 mfd. 250 v., 2/9 each or in lots of six, 2/3 each.

BRAND NEW LUCAS MOTOR CYCLE BATTERIES. 6 v. 22 A.H. (In sealed cartons). Limited number available singly, at only 39/6 each. Carr. 3/6. Or 75/- pair. Carr. 5/-.

INSULATED STAPLES ⅜in. Boxes of 100. Only 1/- each. 10/6 doz. £5/10/- gross.

AC FROM ANY DC SUPPLY WITH

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DC/AC CONVERTERS

★ *Tape Recorders*
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★ Recording outdoor events
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VALRADIO LIMITED
(DEPT. WW/6) BROWELLS LANE · FELTHAM · MIDDLESEX
TELEPHONE: 4242 & 4837

MINIATURE COILS

FOR TRANSISTOR RADIO CIRCUITS

These are the smallest screened coils available on the British market or the Continent.

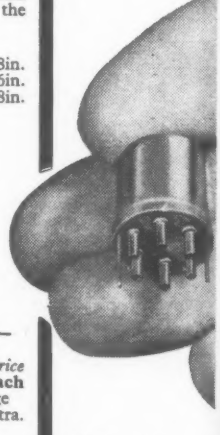
DIMENSIONS:—
Height (Excluding Lugs) .. 5/8in.
Diameter (Top) 9/16in.
Diameter (Base) 5/8in.

★Latest high-efficiency ferrite pot cores and litz windings.

★High Q for maximum gain and selectivity.

★Coupling ratios carefully designed to match latest R.F. transistors. I.F.—460/470 Kc/s.

★Low-loss moulded nylon formers.



THREE TYPES AVAILABLE:—

List		*List Price*
735	Oscillator Coil	11/3 each
736	1st or 2nd I.F. transformer.	postage
737	3rd I.F. transformer	6d. extra.

Connection diagram supplied.
DELIVERY: Ex Stock.
C.W.O., or C.O.D. (1/6d. extra).

Trade, Manufacturers, and Export enquiries invited.

Orders and enquiries direct to the manufacturers :—
CHANNEL ELECTRONIC INDUSTRIES LTD.
COMPONENTS DIVISION
DUNSTAN ROAD BURNHAM-ON-SEA SOMERSET. Phone 3167.

Best Buy at Britain's

MONITOR TYPE 61. 3½in. C.R. Tube. AC mains power pack. Very modern design. Ideal for conversion to Oscilloscope, full data supplied. Condition as new. **£8/19/6,** carr. 15/-.

TRANSMITTER TYPE 36. A complete 50 Watt transmitter for phone or CW. Covers 10-40 Mc/s. Tested and ready to plus into A.C. mains. **£12/10/-,** carr. 30/- Eng. & Wales. For full details see previous adverts or send S.A.E.

VHF TRANSMITTERS. BC-950A-130 100-150 Mc/s., 4 channel, crystal controlled transmitter. Complete with valves-2 of 1625, 2 of 832A, 1 of 815 (modulator). **BRAND NEW.** In original American packing. (Xtal not supplied). **£5/19/6.** Carr. 7/6.

BEACON TRANSMITTER-RECEIVERS RT37/PPN2. Contains 5 3A5, 3 1S5, 1 1S5, and two 2 Volts vibrapacks. Complete in haversack with telescopic mast antenna, lightweight phones, manual etc. **BRAND NEW.** Special reduced price, 65/-, carr. 7/6.

AVOMETER MODEL D. 34 ranges. Large size AVO. For full details see previous adverts. Thoroughly overhauled. Complete with batteries and instructions. **£8/19/6,** post 4/-.

SANGAMO-WESTON ANALYSER E772. A useful multi-range meter in Rexine covered carrying case. Thoroughly overhauled and in perfect working order For full details see previous adverts. **10 Gns.,** carr. 4/-.

TRIPLETT COMBINATION TESTERS. Valve tester and multimeter combined. 10,000 ohms per volt. Complete with batteries, instructions, and tested ready for use on A.C. mains. **BRAND NEW. £14/19/6,** Carr. 7/6. See illustrated advert. p. 140 May W.W.

MULLARD C. & R. BRIDGES. 0.1 Ohm to 10 Megohms in 4 ranges; 10 pFd. to 10 mFd. in 3 ranges; Calibrate, Open Bridge, and % ranges. For 100-250 V A.C. mains. Tested and guaranteed. **£7/10/-.** Post 3/6.

ADMIRALTTY HT TRANSFORMERS. Pri. 230 V. 50 c/s. Secs. 620-550-375-0-375-550-620 V. (620 and 550 V. 200 m/Amps., 375 V. 250 m/Amps.), plus two 5 V. 3 Amp. rectifier windings. Total rating 278 VA. Upright mtg. Wt. 25 lbs. Made 1953. **BRAND NEW.** Original boxes. 45/-. Carr. 5/-.

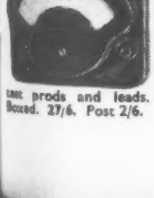
MAINS ISOLATING TRANSFORMERS (Vortexion). Fully shrouded. For testing A.C./D.C. sets in safety. 230 v. input. Output 230 v. 100 watts, **22/6.** Post 2/6.

DUAL PURPOSE TRANSFORMERS (Gresham). Pri. 230/250 v. Secs., 240-0-240 v. 1.5 amps., 5 v. 12.5 amps., 5 v. 1.75 amps. Ideal for ISOLATING TRANSFORMER, to obtain TWO 240 v. 360 watt lines. Potted, oil-filled, 7 x 7½ x 10½in. high. Wt. 50 lb. **BRAND NEW. £3/10/-.** Carr. 10/-.

MARCONI LOOP AERIAL type 696. A small, compact, enclosed loop. On swivel mount with degree scale. **BRAND NEW. 69/6.** Post 2/6. Ideal for R1155, etc.

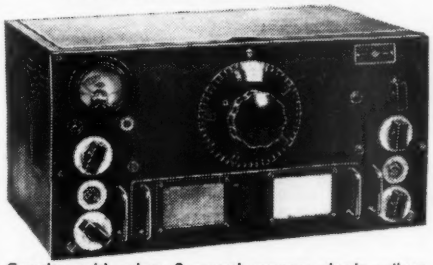
BATTERY CHARGERS. Input 230 v. A.C. Output 12 v. D.C., 1.5 amps. In neat grey metal case, 7 x 6 x 5in. **BRAND NEW, 35/-.**

CRYSTALS. 200 Kc/s. American GEC, 10/- each. 100 Kc/s. RCA bars, **15/-.**



SANGAMO-WESTON VOLTMETERS S61. Dual range 0-5 & 0-100 V. D.C. FSD 1 m/A. 3in. scale. Recent manufacture. Ideal for schools. Complete in super quality canvas carrying case, with test prods and leads. **BRAND NEW.** Boxed. 27/6. Post 2/6.

HRO SENIOR MODELS



Complete with valves, 9 general coverage plug-in coilsets 50 Kc/s. to 30 Mc/s., instruction booklet, and circuit, but less external power supply unit.
Table models, as new condition, **21 GNS.** Rack Mounting, **18 GNS.** Packing and carriage 22/- extra.
Send S.A.E. for further details.

METER BARGAINS

RANGE	TYPE	SIZE		PRICE
50 Microamp.	D.C. M/C	2½in.	Flush Circ., scaled 0-100	59/6
100 Microamp.	D.C. M/C	2½in.	Flush Circ.	42/6
100 Microamp.	D.C./M.C	2½in.	Flush Circ., scaled "Megs."	39/6
500 Microamp.	D.C. M/C	2in.	Flush Circ. Ex 19 Set	12/6
1 Milliamp.	D.C. M/C	2in.	Flush Square. Fe/NFe.1954	22/6
1 Milliamp.	D.C. M/C	2½in.	Flush Circ. Made 1954	25/-
1 Milliamp.	D.C. M/C	3½in.	Flush Circ.	35/-
1 Milliamp.	D.C. M/C	6in.	Flush Circ. Scaled 0-12 v.	79/6
200 Milliamp.	D.C. M/C	2½in.	Flush Circular	10/6
1 amp. Thermocouple		2½in.	Projecting Circular	6/9
1 Amp. Thermocouple		2½in.	Flush Circular	7/6
4 Amp. Thermocouple		2in.	Flush Square	6/9
15 Volts	A.C. M/I	2½in.	Flush Circular	9/6
300 Volts	A.C. M/I	6in.	Flush circular. Made 1955	79/6
300 Volts	A.C. M/I	2½in.	Flush Circular	25/-
500 Volts	A.C. M/I	2½in.	Flush Circular	25/-
40 Amperes	D.C. M/C	2in.	Flush Circular	7/6

METER RECTIFIERS. Full wave bridge. Brand new, Salford 1 mA. 6/6. 5 mA., 6/6. STC 2 mA., 5/6.

AMERICAN METERS. Triplett 100 microamp., 4in. meters, scaled as multimeter. exactly as used in Combination Tester. Brand new, boxed, **79/6.** Post 1/6.
Triplett 100 microamp, 3in. square, flush mtg. Scaled as output meter, 1.5 and 0-6 volts A.C. Rectifier not fitted. Brand new, boxed, **42/6.** Post 1/-. Westinghouse 0-5 Milliamp D.C., flush mtg., circular, 2in. blank black scale. Brand new, boxed, **8/6.** Post 1/-.

AMERICAN MULTIMETERS

A good general purpose portable meter by Precision, U.S.A. Basic, FSD 400 micro-Amps. Ranges: A.C. and D.C. volts 0 to 12, 60, 300 600, 1,200 and 6,000; D.C. milli-Amps. 0 to 1.2, 12, 60 and 600; Ohms, 0 to 5 K. 500 K. and 5 Meg.; —10 to + 16 dB. In polished wooden case with carrying handle and compartment for leads, etc. Size 7½ x 7½ x 5½in. Complete with batteries, tested and guaranteed. **£6/19/6.** Post 2/6.

ADMIRALTY POWER UNITS. Equivalent to AM234. Input 200-250 v. 50 c/s. A.C. mains. Outputs 240 v. D.C. 125 m/Amps. and 6.3 v. A.C. 6 amps. Dual purpose 2½in. panel mounted 300 v. meter reads input and H.T. volts. Double smoothing with paper capacitors. Standard 19in. rack mounting. **BRAND NEW. 79/6.** Carr. 7/6.

MEGGERS

Evershed and Vignoles Wee Meggers. 500 Volts. Complete in leather case, with leads and instruction booklet. **BRAND NEW, £12/10/-.** Ditto as new, **£8/19/6.** Ditto, but 100 Volts. **BRAND NEW £6/10/-. E. & V. SERIES 2 MEGGERS.** 500 Volts. 0-100 Megohms. In leather case. First class condition. **ONLY £16.**
INSULATION TESTERS by Record Electric. 500 Volts. 0-50 Megohms. Tested and guaranteed. **ONLY £8/10/-.**

MINIATURE 373 IF STRIPS. For FM tuner described in "Practical Wireless." Complete with 3 of HF91, 2 of EL92 and 1 of EB91. A fresh release enables us to offer these once again. **BRAND NEW.** Complete reprint of conversion instructions and circuit supplied free. **42/6.** OE less valves, **12/6.** Post, either, 2/6.

MARCONI SIGNAL GENERATORS

85 Kc/s. to 25 Mc/s. A.C. mains operation. In fair condition and working order. TF144F, **£45.** TF144G, **£50.**

CR100 SPARES KITS

Contents: 15 valves, 2 of U50, DH63, KT63, X66, and seven KTW61 or KTW62. Output transformer, Resistors, Condensers, Potentiometers, PK screws, pilot lamps, drive cord, etc. etc. **ALL BRAND NEW. 59/6.** Post 4/6.

R1155 RECEIVERS. Model "B" with latest type SM drive. In good condition and perfect working order. Realigned and air-tested. S.A.E. for details of power packs, etc. **£7/19/6.** Carr. 10/6.

TECHRAD AMPLIFIERS (U.S.A.). High sensitivity, suitable for crystal, moving coil, or ribbon microphones/pickups, etc. Output 12 watts into 600-15-7.5-5.2.5 ohms. Complete with four 6J7 met., two 6L6GA, one 5U4G, and ready for use on 200-250 V A.C. mains. In grey crackled steel case 17 x 10 x 10in. Absolutely **BRAND NEW £13/10/-.** Carr. 10/-.

BENDIX MODULATOR/POWER UNITS. Type MP-28-BA, for TA-12 transmitters. With 24 V. D.C. input, 540 V. D.C. 450 m/a. output dynamotor, 6N7met Mic. Amp., 6F6met Driver, and two 807 P.P. Modulators. Complete with Mic. Transf. and Mod. Transf. for modulating two parallel 807's. Brand new **79/6.** Slightly soiled **69/6.** Carr. 7/6.

DYNAMOTORS. As used in the above. Brand new **32/6.** Used **19/6.** Wt. 13lb. Carr. 4/-.

MARCONI TF.340 OUTPUT METERS. Perfect working order. **£29/10/-.**

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25 Ranges: 0 to 5, 25, 100, 250, 1,000, and 5 kV. D.C. (20,000 OPV); 0 to 5, 25, 100, 250, and 1,000 v. A.C. (1,000 OPV); 0 to 50 microA, 1, 10, 100 and 500 mA 1 and 5 amps D.C.: 0 to ½, 1, 5 and 10 amps. A.C.; 0 to 1,000, 100 K, and 10 megohms. Square meter, size 4 x 4in. Contained in 11½ x 8 x 5½in. wooden case, weight 10lb. Supplied complete with instruction book, batteries, leads and special high voltage leads. **BRAND NEW** ready for use and fully guaranteed **15 gns.** Post 5/-.

VIBRATOR PACKS. Input 6 v. D.C. Output approx. 100 v. D.3. at 30 m/amps.. fully smoothed and R.F. filtered. Size 6½ x 5 x 2in. Fitted with Mallory 629C vibrator. **BRAND NEW.** Boxed. **12/6.**
ANOTHER, but 200 v. D.C. 100 m/amps. With OZ4 valve and vibrator. **BRAND NEW.** Boxed. **25/-.**

RCA OUTPUT TRANSFORMERS. As used in MI-11220 Amplifier. Primary for push-pull 6L6's. Secondaries 5, 7.5, 15, and 600 ohms, and tertiary for NEB. 25 watts power rating. Potted construction, with tag connections Full circuit of RCA amplifier supplied. **BRAND NEW, 27/6.** Post 2/-.

AR77 MAINS TRANSFORMERS. Fully shrouded, drop-through 3¾in x 3¼in. Primary 110/125/150/210/240 v. 50-60 c/s. Secs., 325-0-325 v. 100 m/amp., 6.3 v., 3.5 amp., and 5 v. 2 amp. **BRAND NEW** ex-U.S.A., **29/6.**

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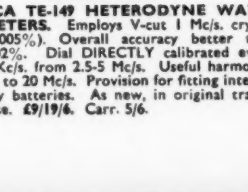
USA RELAYS. 25 Ohms coil operates from 3 Volts. 4 pole C/Over and 1 make. Brand new. Boxed. **8/6** post paid.



RCA TE-149 HETERODYNE WAVEMETERS. Employs V-cut 1 Mc/s. crystal (0.005%). Overall accuracy better than 0.02%. Dial DIRECTLY calibrated every 1 Kc/s. from 2.5-5 Mc/s. Useful harmonics up to 20 Mc/s. Provision for fitting internal dry batteries. As new, in original transit case. **£9/19/6.** Carr. 5/6.

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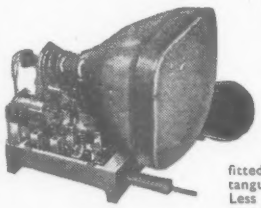


17" T.V. CHASSIS TUBE & SPEAKER £19/19/6.

Latest improved circuits. Higher E.H.T. (brilliant picture), improved sensitivity (for greater range). Chassis is easily fitted into any cabinet. 17in. rectangular tube on adapted chassis. Less valves. 12 months guarantee on tube, 3 months guarantee on valves and chassis. With valves £25/19/6. Valve line-up: 6SN7G, 6V6, EY51, 6 D2, EL38, EL41 and 7-6F1's Turret tuner 50/- extra. State B.B.C. and I.T.A. channel required. Extra channel supplied at 7/6 each. Ins., car. (incl. tube) 25/-.

14" T.V. CHASSIS TUBE & SPEAKER £13/19/6.

As above with 14in. round tube. Less valves. 3 months guarantee. With valves £19/19/6. Turret tuner 50/- extra. Ins., car. 25/-.

T.V. AERIALS 25/6.

For all I.T.A. channels. Outdoor or loft. Three element. Famous manufacture at half the normal price. Post 2/6.

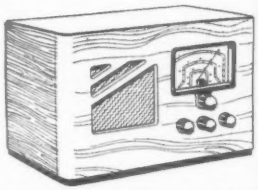
GANG CONDENSERS 1/9. Two and three gang, 500 pf., standard, salvaged, tested. P. & P. 1/3.

ATTRACTIVE EXTENSION SPEAKERS IN CABINETS 29/9.

Complete. Fitted with an 8in. P.M. speaker, HIGHEST quality. Standard (2–5 ohms). Flex and switch included. Unrepeatable at this price. Ins., car. 3/6.

8in. P.M. SPEAKERS 8/9. With O.P. TRANS. 10/-. P. & P. 2/9.

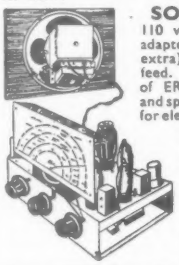
HOME RADIO 79/6.



Five valve (octal) superhet. Three waveband receiver A.C./D.C. Universal mains can be adapted for gram. P.U. In wooden cabinet 9½ x 18½ x 11¾in. Ins., car. 7/6.

17" £7/10/0 (RECT.) T.V. TUBES (USED) 14" £5/10/0 (RECT.). 12 months guarantee.

Six months full replacement, six months progressive. Made possible by the high quality of our tubes. Ins., car. 15/6. Convert your 9in., 10in., 12in. tubes to 14in., 15in., 16in. (round tubes). Our special offer for these sizes £5. Full instructions in our FREE CATALOGUE. 12in. T.V. TUBES £6. Three months guarantee on round tubes. Ins., car. 15/6 on all tubes.



SOLO SOLDERING TOOL 19/6.

110 v. or 6 v. (special adaptor for 200/240 v. 10/- extra). Automatic solder feed. Includes a 20ft. reel of ERSIN 60/40, solder and spare parts. It is a tool for electronicsoldering or car wiring. Revolutionary in design. Instantly ready for use and cannot burn. In light metal case with full instructions for use. Post 2/9.

SUPER CHASSIS 99/6.

Five valve superhet chassis, including 8in. P.M. speaker and valves. Four control knobs (tone, volume, tuning, w/ change switch). Four w/m and with position for gram. P.U. and extension speaker. A.C. Ins., car. 5/6.

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4-SPEED PLAYERS. (while they last)

WITH STAAR GALAXY AUTOCHANGERS, LIGHTWEIGHT DUAL SAPPHIRE TURNOVER P.U. A.C. 200/250 v. (Listed approx. £15.). THIS YEAR'S BARGAIN. High finish case as illustrated. (Post 4/-.) **£5.15**

4-SPEED PLAYERS. Above Changer, 3 Valve Amplifier, 7in. speaker in two-tone Portable Attache Case (worth £20). 13 GNS.

GALAXY SPARES. Motors 200/250V AC, 12/6. Rubber idler wheels, 4/6. Power point cartridges, 12/6. Sonotone cartridges, 19/6. Etc., etc. Enquiries welcomed.

TRANSISTORS

RED SPOT (up to 800 Kc/s). Guaranteed..... 7/-
BLUE SPOT (up to 1.6 Mc/s.) Guaranteed..... 10/-
WHITE SPOT (up to 2.5 Mc/s.) Guaranteed..... 14/-

GUARANTEED T.V. TUBES (EX EQUIPMENT)

12in. (MW31-74, CRM121, 3/31, etc.)	£5	5	0
14in. (MW36-24, C14BM, 4/14, etc.)...	£4	10	0
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17in. (CRM171 only).....	£6	0	0

(All guaranteed 6 months) (carr. & ins. 12/6)

GUARANTEED RADIO VALVES, BOXED, 24-HOUR SERVICE

5U4G	6/6	6L6G	8/-	12Q7GT	7/6	ECC84	10/6	PEN45	15/-
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6AC7	5/6	6SA7M	7/-	25Z5	9/6	ECF80	12/-	PCC85	11/6
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6AL5	5/6	6SJ7M	7/6	41	9/6	EF36	4/-	PCF25	5/-
6AM6	6/6	6SKGT	5/-	42	9/6	EF37	7/-	PL81	13/6
6BA6	6/6	6SN7GT	5/9	43	9/6	EF37A	8/-	PL83	9/-
6BE6	8/6	6U4GT	12/6	80	7/6	EF39	5/-	PL83	11/-
6C4	4/9	6V6G	6/-	83	7/6	EF50(BR)	4/6	PM12M	5/6
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6D6	4/6	6V6M	7/-	807(AM)	5/6	EF80	11/-	PY81	8/6
6H6	2/-	6X4	6/-	EA50	1/6	EF85	7/-	PY82	8/6
6J5M	5/-	6X5GT	5/-	EB34	1/6	EF89	9/6	SP4B	9/6
6J5GT	4/6	7B7	7/6	EB91	5/6	EF91	6/6	SP13C	11/-
6J5G	5/-	6C6	7/6	EBC33	7/-	EF95	8/6	SP41	2/6
6J6	4/6	12A7M	8/6	EC52	5/-	EL32	5/6	SP61	2/6
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All items less 5% and post free for a dozen or more

Postage 1/- in £1 (1/9 in £1 Speakers/Trans.). Min. 6d. No C.O.D.

100 TELEVISION SET BARGAINS TO CALLERS AT :—

350/352, FRATTON ROAD, PORTSMOUTH

BE TRANSISTORWISE and build these fine transistor kits

" RECO " TRANSISTOR ONE WITH Vari " Q " ferrite coil 180 to 500M., personal phone, etc. Case size 4½in. × 4½in. × 1¼in. Complete kit 30/-. P.P. 2/-. With long waves 3/6 extra.

" RECO " MIDDY TRANSISTOR TWO

An amazing receiver which on test (50 miles from London) received Continental stations with only a few yards of aerial wire. The Home and the Third were received on built-in Vari " Q " ferrite rod aerial. All parts and plastic case 4½in. × 3¼in. × ⅞in. and balanced armature output unit 49/6. With miniature earpiece 55/-. P.P. 2/3. Middy 2 is similar to 3 but less sensitivity control.

" RECO " SPECIAL TRANSISTOR THREE

This fine receiver has now been greatly improved with the addition of a handsome looking chromium plated telescopic aerial 11½in. closed, 48in. extended. Has sensitivity control and High " Q " Frame aerial. Complete kit with choice of " Sonotone " miniature earphone or balanced armature output unit which, in areas of reasonable signal reception, can be mounted inside case. Case size 6¼in. × 4¾in. × 1¼in. with red plastic ornamental unit cover. 77/6. Less telescopic aerial and with balanced armature output unit 65/-.

" RECO " MIDDY TRANSISTOR THREE

Small in size, big in performance. Ideal for invalids. Take it on holiday. Vest pocket size 4¾in. × 3¼in. × ¾in. In areas of reasonable signal reception receives local stations on built-in ferrite rod Vari " Q " aerial. Covers 180 to 500 metres. Complete with three transistors and pencell. Price including " Sonotone " miniature earphone with moulded ear insert and lead 65/-. *Overseas orders. Carr. 10/- extra.* All " Reco " kits with ferrite rod aerials can now be supplied either for Medium and Long waves (3/6 extra) or Medium and Short waves. Please state preference. Cases finished in red/black or red/coral pink 3/6 extra. P.P. 2/3.

Pictorial wiring diagrams parts price list for all the above 2/6.

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WE SELL QUALITY at Our SELF SERVICE SURPLUS STORES

PLESSEY SPEAKERS
7in. x 4in. elliptical 3 ohms **18/6**, post paid. 5in. circular, 3 ohms, **17/6**, post paid.

CONVERTORS. Easily the most useful units released by the Ministry. Within minutes you can extend the frequency of any receiver to cover the following:— R.F. 26 50–65 Mc/s Variable tuning **20/-**. R.F.25 40–50 Mc/s , switched tuning **8/6**. All Brand New with circuit, 3/6 postage on each.

MONITOR, TYPE 61. A First-Grade Synchroscope designed for D.C. Pulse and R.F. Envelope investigation, and employs a 3½in. CRT type VCR138A. R.F. Frequency 180/220 Mc/s approx.; and is tuneable in that range. Has internal 500 kc/s. Calibrating Oscillator on Y Plates. Existing Time Base Speeds are 50 cycles, 20 Micro-seconds fast, and 1,000 Micro-seconds slow. Conservatively rated Mains Power Pack is for nominal 115 v. and 230 v Is an excellent general purpose Oscilloscope. Size 10½in. x 12½in. x 19in. deep. **£10/10/-**. Carr. 10/-.

INDICATOR UNIT 277
Consisting of one inch C.R. tube type VCR522, 6 valves:—4-EF50, 2-VR92. Incorporates Focus, Brightness, and Gain controls. Size 7 x 10 x 5in. Manufactured by Cossor Only **65/-**. P. & P. 3/6.

S.T.C. RECTIFIER UNIT. Input 100-250 v. A.C. Output 115 v. D.C. at 1 amp. Provision for adjustment of 3 and 12 volts either side of mean voltage. **55/-**, carr. 5/-.

GELOSO V.F.O. UNITS. Type 101 covering 80, 40, 20 15 and 10 metres, single end output, using 1-6J5, 1-6AU6, 1-6V6. Complete with calibrated dial and escutcheon. Less valves **£7/12/6**. P & P. 2/6.

HEADPHONES—BRAND NEW. High resistance 4,000 ohms **11/6**. P.&P. 1/6. Low resistance 120 ohms **6/6**. P.&P. 1/6.

COMPLETE HEADPHONE AND MICROPHONE ASSEMBLY. Consisting of padded headphones and No. 7 moving coil hand microphone with cord and plug. Brand new. Price **10/-**. P. & P. 3/6.

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LUMINOUS MAGNETIC MARCHING COMPASS. Pocket size. Brand new with instructions. ONLY **12/6**. P. & P. 1/-.

866A VALVES. New and boxed, **13/6**. P. & P. 1/6

COMMUNICATION RECEIVER RA 1B. Covers 150 kc/s-15 Mc/s in 6 bands, 12 or 24 operation. S.A.E. for details.

HOOVER ROTARY TRANSFORMER. 11.5 volts input, 490 volts output at 65 mA. **27/6**.

I.F. TRANSFORMERS. 465 kc/s. **7/6** pair. P. & P. 1/-.

AMERICAN ROTARY CONVERTORS
With cooling Fan. Input 12 v. D.C. Output 250 v. at 90 mA. Completely suppressed. Only **17/6** each. P. & P. 3/6.

No. 18 TRANSMITTER/RECEIVER
A portable, self-contained Transmitter/Receiver for Telephone and C.W. Range approx. 10 miles. Frequency 6-9 Mc/s. (50-33.3 metres). Valve line-up: 3 ARP-12, 2 AR-8, 1 ATP4. Complete with aerial, H.T. and L.T. meter. Weight 20lb., size 8 x 10 x 17in. Only **60/-** Carr. 10/-.

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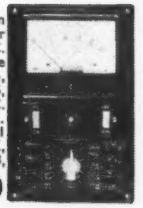
MODEL AN/20 MICROTESTER is a magnificent 18-range universal multi-test meter. High sensitivity type (5,000 ohms per volt on all ranges) and has accurate linear scales for the lower A.C. voltage ranges. Pocket size and complete with test leads.
Ranges:
0 to 2.5, 10, 50, 250 and 1,000 D.C.
0 to 2.5, 10, 50, 250 and 1,000 A.C.
0 to 1, 100, 1,000 M.A. D.C. 0 to 15 K, 1.5 megohms. 0, +13, +27 Db (0 Db = 6 Mw into 500 ohms).
Brand New £9.9.0

MODEL AN/27 TEST METER. An accurate, high sensitivity (5,000 ohms per volt on all ranges), 27-range A.C./D.C. instrument. Housed in a leatherette covered case with tool storage provision, complete with leads. Ranges: 0 to 2.5, 10, 100, 250, 500 and 2.5 KV D.C. 0 to 2.5, 10, 100, 250, 500, 2.5 KV A.C. 0 to .25, 2.5, 25, 250, 500 MA D.C. 0 to 1 and 5 amperes D.C. 0 to 2.5 K, 25 K, 250 K and 2.5 megohms. 0, +20, +28, +34 Db (0 Db = 6 Mw into 500 ohms).
Brand New £15.15.0



RELDA MAINS TRANSFORMERS
(Fully Guaranteed)

Interleaved and impregnated. Primaries 200-230-250 v. 50 c/s. 250-0-250 v. 80 mA., 6.3 v. 3.5 a.; 4 v. 4 a.; 0-4-5 v. 2 a.	22/6
350-0-350 v. 80 mA., 6.3 v. 3.5 a.; 4 v. 4 a.; 0-4-5 v. 2 a....	22/6
250-0-250 v. 100 mA., 6.3 v. 3.5 a.; 5 v. 2 a.....	25/6
300-0-300 v. 100 mA., 6.3 v. 3.5 a.; 5 v. 2 a.....	25/6
6.3 v. 2.75 a. Filament transformers.....	7/6
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Post and packing 1/6 on each.

2-way TELEPHONE KIT

Install your own intercom.!!! with this brand new kit consisting of 2 "press to talk" hand telephones, long life battery, 100ft. of flex and simple wiring details. Ideal for garage, office, workshop, factory, farm, camping, and home. Will give endless hours of pleasure and has proved reliable under all conditions. Complete kit sent for only **25/-** P. & P. 3/6.

813 VALVES U.S.A. 70/-

WHEATSTONE BRIDGE

Consisting of four stud switches: 0-10 ohms, 0-100 ohms 0-INF. Galvanometer centre zero F.S.D. 2.5 mA. Ranges easily extended. Housed in oak cabinet 16 x 7¼ x 6in.
Complete with instructions. **40/-** P.&P. 4/-.

NO. 19 ATTACHMENTS

Supply units.....	30/-
Variometers.....	20/-
Headphone and microphone assembly	13/6
Morse key assembly	4/6
12ft. aerial	7/6
Control box, single	5/6
Control box, double	8/6

COMMUNICATION RECEIVER R1155 This magnificent receiver covers 5 ranges: 75–200 kc/s., 200-500 kc/s., 600-1,500 kc/s., 3-7.5 mc/s., 7.5-18.5 mc/s. Fully tested before despatch. Complete with circuit and instruction booklet. **£7/10/-**, carriage 10/-.

INFRA RED MONOCULAR. Ideal for night viewing, etc. Complete with push-button power unit and focus lenses. Brand new in beautiful leather carrying case. Originally cost Govt. £40. OUR PRICE **25/-**. P. & P. 3/6.

R.T.-7/APN-1 ALTIMETER TRANSCEIVER. Brand new complete with 14 valves: 3-12SJ7, 4-12SH7, 2-12H6, 1-VR150, 2-9004, 2-955. Famous Wobbulator Unit. Dynamotor, Relays 3,500 ohms and 6,500 ohms. A.F. amplifier. Receiver section covers 400-450 mc/s. Transmitter sweeps 418 to 462 mc/s. Ideal for model control work, etc. Only **35/-**. Carriage 10/-.

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PACKARD-BELL PRE-AMPLIFIER. Complete with 1-28D7, 1-6SL7GT, miniature relay, push pull input and output transformers, miniature 8 way plug and socket, switch and jack plug. Size 5in. x 3½in. x 4in. Complete with circuit. **17/6**. P. & P. 2/6.

No. 46 TRANSMITTER/RECEIVER for R/T and M.C.W. for frequencies between 3.6-9.1 Mc/s. Fixed crystal controlled. Weight 9lb. Size 6½in. x 12in. x 4in. Complete with 6 valves and circuit. Less crystals and coil unit **50/-**.

METERS. 500 micro-amp. 2in. circular, calibrated 0-15 and 0-600 volts, **17/6**, P. & P. 1/6. 0-1 mA. 2in. square **22/6**. P. & P. 1/6. 1 amp. R.F. 2in. circular **5/6**. P. & P. 1/-.

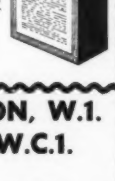
ARMOUR RECORDING WIRE. U.S.A. top quality on original reels, length 3,700 yds. **10/-**. P. & P. 1/6.

RELAYS. 6,500 ohms and 3,500 ohms. **8/-** pair. Post paid.

COLVERN WIRE WOUND POTENTIOMETER. 25 watts 50k and 100k. Price **6/-** each.

MUIRHEAD VERNIER SLOW MOTION DRIVES. Scaled 0-180 deg. Ratio 25 to 1. 3in. dia. **10/6**, P.P. 1/6.

LEAD ACID ACCUMULATORS (unspillable). 2 volts 16 A.H. Ideal for 6 volts and 12 volts supply. Brand new original cartons. Size 14in. x 7in. x 2in. **5/6** each. P.P. 1/6; 3 for **15/-**. P.P. 3/6; 6 for **27/6**. P.P. 5/-.



Relda Radio Ltd.

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32A, COPTIC STREET, LONDON, W.C.1.

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AVO Multiminor 19 Range Meter

£9.10 or 10/- down and 19 weekly payments of 10/-. Like all AVO meters it is a very fine instrument: it has a sensitivity of 10,000 ohms per volt and 19 most useful ranges as follows: D.C. volts 0-1,000 (seven ranges), A.C. volts 0-1,000 (five ranges), D.C. Current 0-1 amp. (five ranges), resistance 0-2 megs. (two ranges) (complete with test leads), immediate delivery,

10/- down

METAL RECTIFIERS
Westinghouse

18RA 1—1—8—1	4/3	14A86	18/-
18RA 1—1—16—1	6/3	14A97	23/10
16RC 1—1—16—1	9/-	14A100	26/1
14RA 1—2—8—2	19/-	14A124	28/4
14RA 1—2—8—3	23/-	14B130	33/9
16RE 2—1—8—1	8/-	LW7	24/10
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		WX6	3/11

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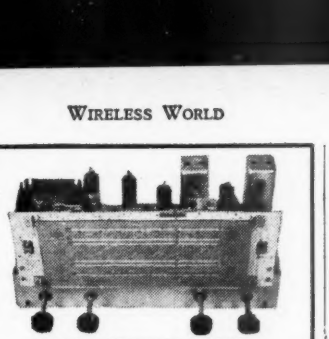

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3V4	8/6	6SN7	8/6	EBF80	10/6
5U4	8/6	6V6G	7/6	ECC84	12/6
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6J7	8/6	80	10/6	EL84	10/6
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½in. × ½in. 100 v. working.
.005 MFD., .0022 MFD., .002 MFD., .001 MFD. 8d. each. .01 MFD., .02 MFD. Price 9d. each. .04 MFD. 10d. each.

DISC CERAMIC CONDENSERS 500 v. Wkg.
.001 MFD., .0025 MFD. .002 MFD., .003 MFD., .005 MFD. 6d. each. .01 MFD. 9d. each.

HIGH VOLTAGE MICAS
100 pF., 140 pF., 5 kV., 300 pF., 8 kV. 9d. each. 100 pF 12 kV, 1/-. 1,000 pF Visconol 20 kV, 5/6 each.

VARIABLE GANG-CONDENSERS
Twin Gang. 20 pF. Ideal for F.M. 2in. × 1½in. × 1in. 2/- each.
Twin Gang. .0005 MFD. 2½in. × 2in. × 1¾in. Spindle ⅜in., 4/- each.
Min. Twin Gang. .0035 MFD. 2½in. × 1½in. × 1¾in. Spindle ½in., 5/6 each.
Min. Twin Gang. .0005 MFD. 2½in. × 1½in. × 1¾in. Spindle ½in. with trimmers, 6/6 each.

METALLISED PAPER TUBULARS
T.C.C. .02 MFD. 350 v.w. 8d. Dubilier. .05 MFD. 350 v.w. 8d. Hunt's. .05 MFD. 500 v.w. 9d. Dubilier .1 MFD. 150 v. 4d. .1 MFD. 500 v.w. 9d.

SWITCHES ROTARY
Size 1⅛in. dia. 2in. spindles. Price 2/11 each.
1 pole 10 way. 1 pole 12 way. 2 pole 2 way. 2 pole 3 way. 2 pole 4 way. 2 pole 5 way. 2 pole 6 way. 3 pole 3 way. 3 pole 4 way. 4 pole 3 way.

WIRE WOUND RESISTORS
5 watt size ⅝in. × 1¼in. 10d. each
7 Ω., 7.5 Ω., 8 Ω., 10 Ω., 12 Ω., 27 Ω., 30 Ω., 33 Ω., 34 Ω., 36 Ω., 39 Ω., 41 Ω., 43 Ω., 45 Ω., 47 Ω., 50 Ω., 51 Ω., 54 Ω., 55 Ω., 56 Ω., 60 Ω., 64 Ω., 66 Ω., 67 Ω., 68 Ω., 70 Ω., 75 Ω., 80 Ω., 82 Ω., 110 Ω., 136 Ω., 160 Ω., 170 Ω., 180 Ω., 250 Ω., 300 Ω., 320 Ω., 330 Ω., 470 Ω., 500 Ω., 560 Ω., 600 Ω., 620 Ω., 800 Ω., 820 Ω., 940 Ω., 1 K., 1.1 K., 1.3 K., 1.4 K., 1.6 K., 1.7 K., 1.8 K., 2 K., 2.2 K., 2.4 K., 2.5 K., 2.7 K., 3.3 K., 4.5 K., 4.7 K., 5 K., 5.2 K., 5.6 K., 5.9 K., 6 K., 6.2 K., 6.5 K., 6.8 K., 7 K., 8.5 K.
6 watt size. ⅞in. × 1½in. 1/- each.
47 Ω., 100 Ω., 250 Ω., 260 Ω., 300 Ω., 350 Ω., 470 Ω., 500 Ω., 560 Ω., 680 Ω., 1 K., 1.6 K., 1.8 K., 1.9 K., 2 K., 2.7 K., 3 K., 4.3 K., 4.7 K., 5.1 K., 5.6 K., 6.2 K., 6.4 K., 6.8 K., 11 K., 13 K., 14.5 K.
7 watt size. ⅞in. × 1¾in. 1/- each.
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HIGH STABILITY RESISTORS
½ watt, ⅓ watt, ¼ watt, 1 watt, 1%, 2%, 5%. Price 1% 10d. 2% 8d. 5% 6d. Please send lists first.

T.V. COMPONENTS
34 Mc/s. I.F. Transformers. Size ¾ × ¾ × 2¼. 1/6.
38 Mc/s. I.F. Transformers. Size ¾ × ¾ × 2¼. 2/-.
Frame Output Transformers. Wide angle, 6/- each.
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Choke. 2 Henries. 250 m/a. 30 Ω res., 3/11 each.
Choke. 1.9 Henries. 230 m/a. 2/11 each.
Choke. 1.3 Henries. 150 m/a., 2/6 each.

PRE-SET TRIMMERS T.V. TYPE
With knurled knob and 6 BA fixing. 750 pF., 1,000 pF., 1/6 each.

VALVE HOLDERS
4 pin Brit. Pax. 2d. each. 4 pin U.X. Amp. 7d. each. 5 pin Brit. Pax. 2d. each. 7 pin Brit. Pax. 3d. each. 7 pin Brit. Amp. 4d. each. 7 pin Brit. Cer. 4d. each. Int. Octal Pax. 3d. each. Int. Octal Amp. 8d. each. Mazda Octal Pax. 3d. each. Loctals Amp. 6d. each. B7G Pax. 6d. each. B7G P.T.F.E. 8d. each. B7G Cer. with saddle and valve retaining spring 1/- each. B7G Cer. with skirt 10d. each. B8A Pax. 4d. each. B8A Amp. 6d. each. B8A Cer. 8d. each. B9A Pax. 6d. each. B9A Amp. 8d. each. B9A Amp. with skirt 10d. each. B9A Cer. 10d. each. B9A Cer. with saddle and valve retaining spring 1/- each. B9A ceramic with skirt 1/- each. B9A printed circuit 1/-.

POTENTIOMETERS CARBON
Less Switch. Dia. 1in., 2¼in. spindles 5 K., 10 K., 25 K., 50 K., 100 K., 250 K., 500 K., 1 Meg., 2 Meg. 2/6 each.
With D.P. Switch Dia., 1in., 2¼in. spindles, 5 K., 10 K., 25 K., 50 K., 100 K., 250 K., 500 K., 1 Meg., 2 Meg. 4/6 each.
T.V. pre-set Controls with knurled knob and 6 BA fixing dia., 25 K., 50 K., 100 K., 250 K., 500 K., 1/3 each. 25 K., wire wound, 1/6 each.

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Westinghouse. 16 RD. 2.2.8.1, 7/- each.
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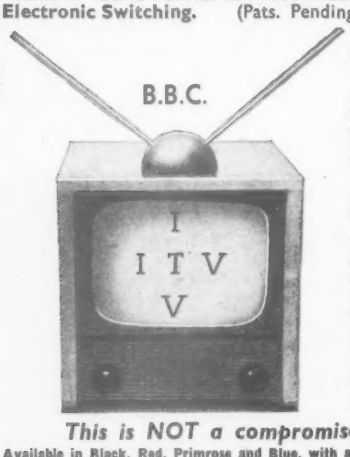

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Each aerial entirely separate, and designed to perform at its respective maximum efficiency.
Now you can effectively lower your installation costs.

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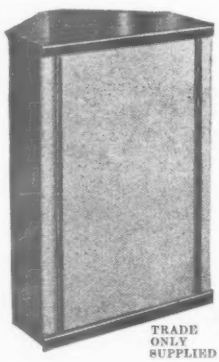

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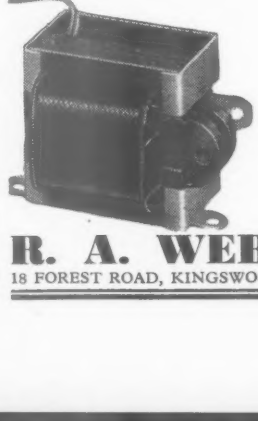

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CCH35	24/4	EF41	9/9	KT36	27/10		8/6	X78	27/1	6B8G	4/-	6SQ7	9/3	14S7	14/6
CL33	20/2	EF42	14/-	KT55	12/6	U22	/-	X79	11/6	6BA6	7/6	6U4GT	14/-	15D2	7/9
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DK96	10/6	EF85	9/-	ME91	7/6	U329	14/6	IA3	3/6	6BR7	11/6	6V6GT	7/-	20P3	24/4
DL96	10/6	EF86	14/6	MH41	7/9	U403	17/5	IA5GT	6/-	6BW6	8/6	6V6M	8/6	20P5	20/11
DM70	8/6	EF89	10/-	MSP4/5	12/6	U404	11/10	IA7	12/6	6BW7	10/-	6X4	7/6	25A6G	11/6
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EAF42	10/6	EL38	27/10	OZ4	5/6	UB41	9/6	ID6	12/6	6C8G	5/-	7B7	8/6	25Z5	10/-
EB34	2/-	EL41	11/-	P61	3/6	UBC41	10/-	IH5GT	10/6	6CD6G	31/4	7C5	8/-	25Z6	10/-
EB41	9/6	EL42	12/-	PCC84	10/-	UBF80	9/6	IL4	6/6	6CH6	7/6	7C6	8/-	30F5	11/6
EBC33	7/6	EL84	10/6	PCF80	13/6	UCC84	20/11	ILD5	3/6	6D6	5/-	7D6	13/6	30FL1	11/6
EBC41	10/-	EM34	10/6	PCF82	12/6	UCF80	23/-	IN5	10/6	6F1	13/6	7H7	9/-	30P4	21/7
EBF80	10/6	EM80	10/6	PCL82	12/6	UCH42	10/6	IR5	8/-	6F6G	7/6	7Q7	9/-	30P12	12/6
EBF89	18/1	EM81	11/6	PCL83	14/6	UCH81	11/6	IS4	10/6	6F6M	7/6	7S7	9/6	30PL1	12/6
EBL21	24/4	EY51	13/6	PL38	27/10	UCL82	23/-	IS5	7/6	6F13	14/-	7Y4	8/6	35L6GT	9/6
EBL31	24/4	EY86	13/6	PL81	16/-	UCL83	25/9	IT4	7/6	6F15	14/-	8D2	2/9	35W4	8/6
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ECC40	12/6	EZ41	10/-	PL83	11/6	UF85	10/6	2C26	1/6	6H6	2/6	10F1	27/10	35Z5GT	9/-
ECC84	10/3	EZ80	8/9	PX25	12/6	UF89	10/6	2X2	4/6	6H6GT	2/6	12A6	6/6	42	8/-
ECC85	9/6	EZ81	11/10	PY80	9/-	UL41	10/6	3A4	7/-	6J5M	6/6	12AH8	11/5	50C5	11/6
ECF80	13/6	EZ90	8/-	PY81	10/-	UL44	27/10	3D6	5/-	6J6	6/-	12AT6	10/6	50CD6G	31/4
ECF82	13/6	E1148	2/-	PY82	9/-	UL46	24/4	3Q4	9/-	6J7G	6/6	12AT7	9/-	50L6GT	8/6
ECH21	24/4	FW4/500	10/-	PY83	10/-	UL84	11/6	3Q5GT	9/6	6J7M	9/-	12AU6	10/6	75	11/6
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				PEN44	27/10	UY85	10/-	5U4G	8/-	6K8GT	10/-	12BH7	11/6	210DDT	4/6
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MT3
Primary 200-220-240 v. Secondary 30 v. 2 amps. Taps at 3 v., 4 v., 6 v., 8 v., 9 v., 10 v., 15 v., 18 v., 20 v., 24 v., 21/9 each. Postage and Packing please add 2/- per transformer.

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2 volt 1 amp.	5/-	5 volt 2 amp.	10/-
2 volt 3 amp.	8/3	6.3 volt 1 amp.	5/6
4 volt 1½ amp.	5/6	6.3 volt 1½ amp.	8/9
4 volt 3 amp.	10/-	6.3 volt 3 amp.	10/-
		12 volt 1 amp.	5/7

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5,000 ohms to 3 ohms. 40 m/A 4/6 each. 10,000 ohms to 3 ohms 30 m/A 4/6 each. 5,000 ohms to 3 ohms 60 m/A 5/- each. Universal output Transformer 18 ratios available, Optimum loads 3,000 ohms to 12,000 ohms, Speech Coil Impedance 2.5 ohms, 12.5 ohms and 15 ohms, current 40 m/A 5/9 each.

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Attractive walnut finished cabinet on black plinth—expanded metal grill, fitted volume control, 8in. P.M. speaker 2-4 ohms. Large purchase from Relay Company of used units as above. Only require removal of matching transformer. All are in good working order.

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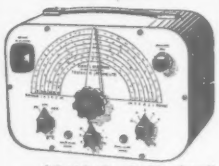

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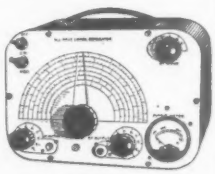
Or **25/-** deposit and 4 monthly payments **21/6**. P. & P. 5/- extra. Coverage 120 Kc/s.—230 Kc/s., 300 Kc/s.—900 Kc/s., 900 Kc/s.—2.75 Mc/s., 2.75 Mc/s.—8.5 Mc/s., 8 Mc/s.—28 Mc/s., 16 Mc/s.—56 Mc/s., 24 Mc/s.—84 Mc/s. Metal case 10in. × 6¼in. × 4¼in. Size of scale, 6¼in. × 3¼in. 2 valves and rectifier A.C. mains 230-250 v. Internal modulation of 400 c.p.s. to a depth of 30 per cent., modulated or unmodulated R.F., output continuously variable 100 millivolts, C.W. and mod-switch variable A.F. output and moving coil output meter. Grey hammer finish case and white panel.
Accuracy plus or minus 2%.



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P. & P. 5/-.

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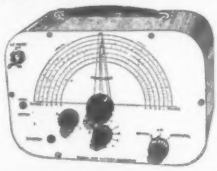
Coverage 7.6 Mc/s.-210 Mc/s. in five bands, all on fundamentals, slow motion tuning audio output, 8 vertical and horizontal bars, logging scale. In grey hammer finished case with carrying handle. Accuracy ± 1%. A.C. mains 200-250 v.



PORTABLE AMPLIFIER

Size 6½in. long, 5in. high, 2½in. deep. Will suit any type of crystal pick-up. Output approx. 2 watts. Incorporating ECC83 double triode, Cossor 142BT output pentode and contact-cooled rectifier. Fully isolated mains transformer **49/6** Plus P. & P. 3/6 for 230/250 A.C. mains. Base, treble and volume controls.

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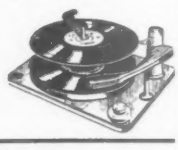

COLLARO MIXER 4-SPEED AUTOMATIC CHANGER

Model 457. Type "O" Pick-up, size 12in. × 13½in. Minimum clearance above baseboard 3in., below 2½in. 10 records A.C. mains 200/250 v. Turnover crystal head. BRAND NEW. Fully guaranteed (suitable for use with above amplifier). **25/-** deposit plus P. & P. 5/- and 7 monthly payments of **25/-**.
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AC/DC POCKET MULTI-METER KIT

Comprising 2in. moving coil meter, scale calibrated in A.C./D.C. volts, ohms and milli-amps. Voltage range A.C./D.C. 0-50, 0-100, 0-250, 0-500. Milli-amps, 0-10, 0-100. Ohms range, 0-10,000. Front panel, range switch, wire-wound pot (for ohms zero setting), toggle switch, resistors and meter rectifier. Basic movement 2 mA. In grey hammer finish case.

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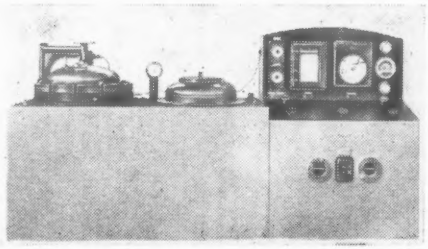

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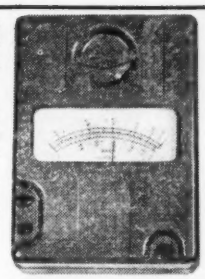

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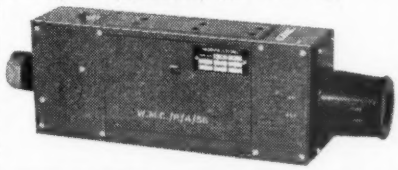
P. & P. on all meters 1/- each.



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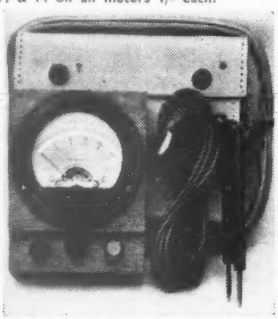

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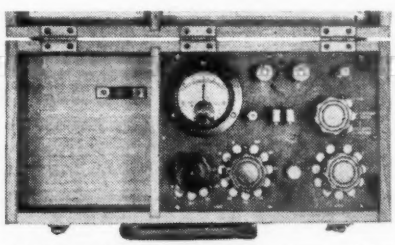
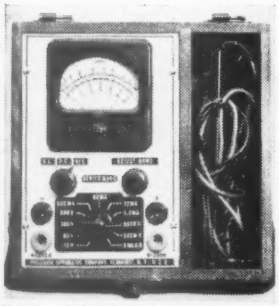


WHEATSTONE BRIDGE UNIT. 4-stud switches 0-10, 0-100 ohms, galvanometer centre zero, F.S.D. 2.5 mA. In oak carrying case 16 x 7½ x 6in. **40/-** each. P. & P. 3/6.

BRAND NEW FINEST CANADIAN MAKE MOVING COIL HEADSETS, complete with moving coil No. 7 microphone, earpieces fitted with soft chamois leather. Ideal for No. 19 Sets and similar equipment. Price **12/6.** P. & P. 2/6.



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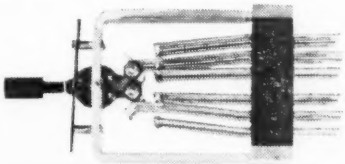

MUIRHEAD PRECISION KEY SWITCHES. Low capacitance, six double sets of contacts each side. Brand new. Chrome-plated bezel. Price **12/6** each. P. & P. 1/-.

MUIRHEAD VERNIER DRIVE. Scaled 0-180 degrees, ratio 31/1, dia. 3in., as fitted to R.F.26 units. Complete with lampholder. In manufacturers' original packing. New, **8/6** each. P. & P. 1/6.

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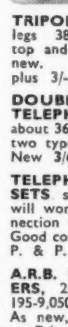

TRIPODS. Solid wooden legs 38in. long, metal top and metal toes. As new. Price **10/6** each, plus 3/- carriage.

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TELEPHONE HANDSETS sound power, pair will work by simple connection without batteries. Good condition, **22/6** each. P. & P. 1/9.

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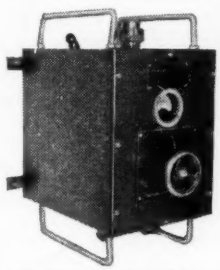

L.T. Transformer, input 230 v. Output 50 v., 50 ampere, adjustable by voltage regulator switch on primary. In steel case fitted with mains switch, will take 100% overload. Grs. Wt. 150 lb. Wound at 800 amps. per sq. in. As illus. above. New in manufacturer's cases. **£15** each. Carriage in England £1.

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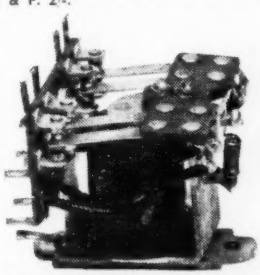

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Send details of your requirements.

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consists of low impedance padded headphones and No. 7 hand microphone with moving coil insert. For use with Army No. 19 set and all other Army Transreceivers

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CRYSTAL CALIBRATORS

1,000 kc/s crystal controlled, with switched 100 kc/s and 10 kc/s locked multi-vibrators.

This excellent unit is as new, and is contained in polished Bakelite case with carrying handle. The circuit uses 6 valves and operates from 2 v. l.t. and 120 v. h.t.

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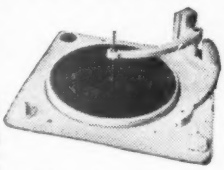
A COMPREHENSIVE RANGE of Hi-Fi speakers by **Goodmans, Wharfedale, W.B., G.E.C., Lorenz,** etc. Tweeter units by **Goodmans, Wharfedale, T.S.L., Elac,** etc.

AUTO-CHANGERS

BRAND NEW OFFER !

COLLARO 4-SPEED AUTO-CHANGERS



Incorporating auto and manual control. Complete with Studio crystal p.u. and sapphire stylus.

Our price Plus 5/– post. **£7-19-6**

NEW COLLARO 457 AUTOCHANGER mixer, with Studio t/o cartridge. **£8/19/6,** plus 5/- post and packing.

B.S.R. 4-speed Model T.U.B. Autochanger, plays 7in. 10in. and 12in. mixed records. Crystal t/o pick-up, **£7/19/6.** (Plus 5/– post and ins.)

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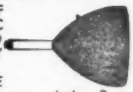

SPECIFICATION 12in. TUBE
Flat face, white fluorescence triode, 2 v. heater, 1.5 a. heater current, anode voltage 10 kv. OUR PRICE **£8/19/6** including mask.
9in. TUBE. Round face, white fluorescence, 4 v. heater, 1 a. heater current, max. anode voltage 7 kv. OUR PRICE **£5/17/6.**

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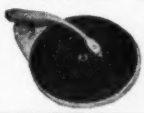
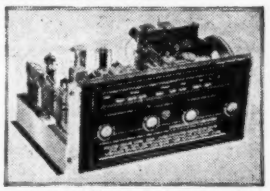


4-SPEED COLLARO
4/546 single player with Studio t/over pick-up. Limited number only. Our price **£6/19/6.** (Plus 5/– post and ins.)

GARRARD 4-SPEED SINGLE PLAYER UNIT with GC2 t/over cartridge for 78 and L.P. records. Our price **£7/10/-,** 4/6 post and ins.

Due to the popularity of this chassis, we have been able to reduce production costs and can now offer our 1958 AM/FM R/G Chassis at **19 gns.** complete.



Eight-valve AM/FM chassis with printed circuit FM tuner section. Illuminated dial in 4 colours; 4 waveband; coverage 1,000-2,000 metres, 200-550 metres, 15-50 metres, 88-100 Mc/s. Dimensions 13x9x6in. Fully guaranteed. Exceptional value—only **19 gns.,** plus 7/6 post and ins.

BRAND NEW 0-1 AMP. 12in. SCALE R.F. METER
Thermo couple **5/-**; 0-300V A.C., 2½in. scale, moving iron meter, **25/-.** Post 2/6.

0–1 M/Amp meter, m/c flush mounting	17 6
0–100 amps 50 cps., 4½in. meter	£2 10 0
0–50 amps moving iron 6in. meter ...	£3 10 0

All brand new and boxed. Post and ins. 1/6.

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1 M/Amp DCO—10 Scale 2½in. Diam.	50/-	500 V.D.C. 0-500 V. (1 KVPV) 3$\frac{9}{16}$in. Diam.	65/-
100 M/Amp DCO—100 M/A 3$\frac{9}{16}$in. Diam.	50/-	1000 V.D.C. 0-1000 V. (20 KVPV) 3$\frac{9}{16}$in. Diam.	95/-
100 Micro Amp D.C. 0-2 M/a 0-250 V. 3$\frac{9}{16}$in. Diam. ...	85/-	300 V.A.C. 0-300 V. 3$\frac{9}{16}$in. Diam.	50/-

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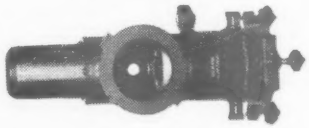
ORDERS ACCEPTED M/A FROM COLLEGES, SCHOOLS, LABORATORIES, ETC.



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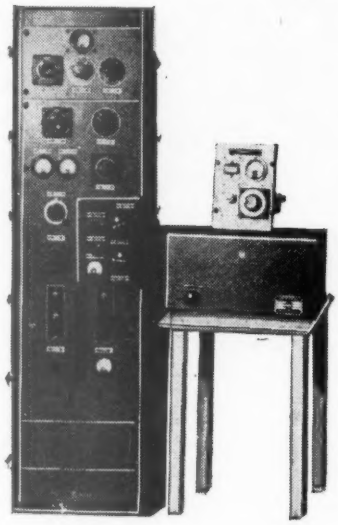

Frequency 2 mc.-20 mc.
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250 w. telephone.
Type of modulation—Class B high level.
Audio input impedance 500 ohms.
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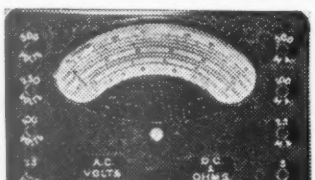

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Condensers 3×.25μF (D and LF), **2/6** each.
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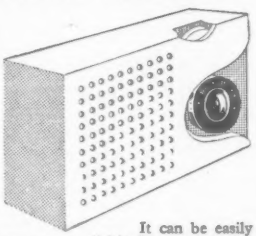

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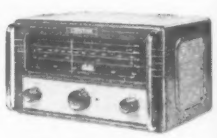

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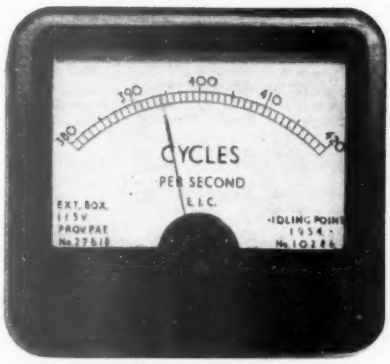

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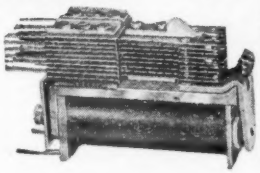

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2.2Ω+ 2.2Ω 1 C O H96A **17/6**
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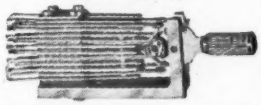

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F.S.D.	Size	Type	Price
50 Microamps	2½in.	MC/FR	70/-
100 ,,	2½in.	MC/FR	50/-
250 ,,	3½in.	MC/FR	55/-
500 ,,	2in.	MC/FS	27/6
500 ,,	2½in.	MC/FR	37/6
1 Milliamps	2in.	MC/FS	27/6
1 ,,	2½in.	MC/FR	35/-
5 ,,	2in.	MC/FR	17/6
30 ,,	2½in.	MC/FR	12/6
100 ,,	2½in.	MC/FR	12/6
200 ,,	2½in.	MC/FR	12/6
300 ,,	2½in.	MC/FR	12/6
5 Amperes	2in.	MC/FS	27/6
15 ,,	2in.	MC/FR	10/6
25 ,,	2½in.	MI/FR	7/6
50-0-50 Amp.	2in.	MC/FS	12/6
30-0-30 ,,	2in.	MC/FR	15/6
20 Volts	2in.	MC/FS	10/6
40 ,,	2in.	MC/FS	10/6
300 ,, A.C.	2½in.	MI/FR	25/-
300 ,, A.C.	6in.	MI/FR	150/-

CROSS POINTER METERS. With 2 separate 100 microamp movements. Brand new. **22/6.** Post 2/-.

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WHEATSTONE BRIDGE. 1 to 210 ohms in 1Ω steps with built-in galvo, 4 stud switches, in wood case with spare compartment. Ideal for extending range. **50/-.** Post 3/6.

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BATTERY CHARGERS. Ideal for charging 24 volt batteries on electrically propelled vehicles. Rating 22 v. 10 amps., controlled by two 4-position rotary switches for fine and coarse control which enables 6/24 v. batts. to be charged. Input 200/250 v A.C. 50 cy., fused for A.C. and D.C. Brand new. **£17/10/-.** Carr. 15/-.

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P.M. SPEAKERS. 12in. Plessey 3 ohms. Special price **32/6,** post 2/-.

P.M. SPEAKERS. 10in., in portable case with flex and plug, **50/-,** carr. 5/-.

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TERMINAL BLOCKS 2-way fully protected. No. 5C/430. **4/-** doz. or box of 50 for **15/-,** 3-way, **6/-** doz., post 1/6.

VOLTAGE REGULATORS. Input 230 v. A.C., 21 amp. Output 57.5 v. to 228 in 16 steps with current limiting reactor. **£12/10/-** each, carriage 15/-.

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Just purchased from the Ministry of Supply, this magnificent 9 valve 3 Waveband receiver gives world wide reception over a coverage of 1.2-17.0 Mc/s. (18-250 metres), taking in several important Amateur Bands, Shipping Band and part of the Medium waveband, including the B.B.C. Light Programme. The sensitivity is 1 micro-volt on C.W. and 2-6 micro-volts on R.T. The controls include a Bandwidth Switch ("Wide" or "Narrow"), choice of AVC and BFO, Audio Filter, RF Gain, Aerial Trimmer. Has built-in Output Stage with Internal Speaker, which can be switched out to use Headphones. Uses normal International Octal Valves. Incorporates A.C. Mains Power Unit for 100-250 volts and Vibrator Pack for 12 volts D.C. In grey metal case size 24 x 13 x 17in. These sets are used, but in first-class condition, thoroughly checked and aerial tested before despatch. Complete, ready to switch on. ONLY **£8/19/6** (carriage 20/- England and Wales, rest of U.K. extra). S.A.E. for leaflet.

COMMUNICATIONS RECEIVER R.1155. The famous Bomber Command Set Covers 18.5-7.5 Mc/s. 7.5-3.0 Mc/s. 1,500-600 kc/s. 500-200 kc/s. 200-75 kc/s. Late Model "B" fitted with Super Slow Motion Tuning. Slightly used, but in First-class Condition, aerial tested before despatch. 14-page booklet supplied giving circuits and notes, etc. (or available separately **1/3**). ONLY **£7/19/6** (carriage 10/6).

A.C. MAINS POWER PACK & OUTPUT STAGE. In black metal case. Enables receiver to be operated immediately by just plugging in. WITH built-in speaker, **£5/5/-**, LESS speaker, **£4/10/-** (carriage 5/-).

TCS TRANSMITTERS

The renowned American TCS Model designed by the Collins Company for static or mobile use. Covers 1.5-12.0 Mc/s. in 3 bands and is complete with 7 valves, employing 2 of 1625 in P.A. Stage, 1 each of 1625 in Buffer and Modulator Stages, and 3 of 12A6 in Oscillator Stage. Provision for VFO or Crystal Control. 4 Crystal positions. Radio Telephone or Radio Telegraph. Has Plate and Aerial Current Meters. Power requirements 12 v. L.T. and 400 v. H.T. In black crackle case, size 11 x 13 x 11in., condition BRAND NEW and UNUSED ONLY **£12/10/-** (carriage, etc., 15/-). The double Dynamotor Power Unit, Type 2188IB for 12-volt operation, delivering 400 v. for Transmitter and 225 v. for Receiver is available at **£12/10/-** (carriage, etc., 15/-).

MARCONI SIGNAL GENERATOR TF-517-F/1. Special offer of these Laboratory Signal Generators. Cover 10-18 Mc/s., 33-58 Mc/s and 150-300 Mc/s. In good used condition, with charts. Checked before despatch. Complete with power pack for normal A.C. mains. ONLY **£12/10/-** (carriage, etc., 20/-).

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6 v. VIBRATOR PACKS. Output approx. 130 v. at 30 mA., fully filtered and smoothed. Complete, ONLY **12/6.**

R1155 SUPER SLOW-MOTION TUNING ASSEMBLY. As used on all late model 1155s. Easily fitted to "A" sets, etc. ONLY **12/6.**

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SPECIAL MAINS TRANSFORMER OFFER. Normal 230 v. A.C. Primary. Secondaries 330-0-330 v. 100 mA. 4 v. 3 amps. Ex-W.D. BRAND NEW AND UNUSED. ONLY **15/-** (postage etc., 2/6).

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CRYSTALS. British Standard 2-pin 500 kc/s., **15/-.** Miniature 200 kc/s. and 465 kc/s. **10/-** each.

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AZ1	12/11	EF40	13/11	PL83	9/11	6AT6	7/6
AZ31	12/11	EF41	9/6	PY80	8/3	6B8G	2/11
CY31	12/11	EF42	12/6	PY81	8/6	6BA6	6/6
DAF96	9/6	EF80	8/6	PY82	8/6	6BJ6	7/6
DF96	9/6	EF86	12/6	TDD4	12/6	6F1	13/11
DK92	9/6	EF89	9/11	UBC41	8/6	6F6M	9/6
DK96	9/6	EF91	6/11	UBF80	9/6	6F13	13/11
DL96	9/6	EL84	9/–	UCH42	8/11	6F15	13/11
DM70	7/11	EY86	15/–	UF41	8/–	6J5G	2/11
EABC80	8/6	EZ80	8 3	UF42	14/6	6K7G	2/11
EBC41	9/6	GZ32	12/6	UY41	7/6	6K8G	7/11
EBF80	9/6	HY90	7/6	ID5	10/6	6L6G	5/11
EB91	5/11	KT33C	8/6	IR5	7/11	6P28	17/6
ECC81	8/11	MU14	8/6	IS5	7/3	6Q7G	8/11
ECC82	8/11	PCF80	12/6	IT4	7/3	6SN7GT	5/11
ECC83	8/11	PCC84	9/–	3Q5GT	9/6	6V6G	5/11
ECC84	8/11	PEN36C	17/6	3V4	8/6	12AH6	12/11
ECC85	8/11	PEN46	6/6	5U4G	6/6	25A6G	12/11
ECH35	10/11	PL33	9/11	5Z4M	10/11	35W4	7/6
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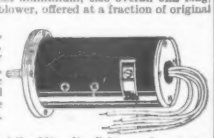
MAINS BLOWER. 200/250 v. A.C./D.C., ½ amp., 5,000 r.p.m., consists of the motor with attached enclosed fan, and funnel intake 1¼in. dia., side outlet 1in. x ¾in., plinth base 5in. x 4¼in., finish black crackle and diecast aluminium; size overall 9in. long, 4¼in. wide, 5in. high weight 7¼lb., a very superior blower, offered at a fraction of original cost, new, unused, **25/-**, post 3/6.

HUGHES MOTOR, shunt wound, 12-v. 1½-amp., speed 5,000 r.p.m., reversing, size 3¼in. long, 1¼in. dia., ¼in. shaft, weight 20 oz., a very superior motor designed for anti-radar equipment, new, unused, **10/-**, post 1/6, **£5** per doz., carriage paid, ditto fitted reduction gear, giving a final drive (¼in. shaft) of either 320 or 160 r.p.m., state which required. **12/6**, post 1/9; **£6** per doz. carriage paid.



LOUDSPEAKERS by Pye, Philips, etc., consists of the 10in. dia. P.M. speaker, 3 ohm coil, less transformer, fitted in a smart brown finished wood case, size 17 x 17 x 6½in., with carrying handle, metal grille at front with 4 smaller ones at rear, rear compartment contains 50ft. superior twin lead fitted standard jackplug, new in sealed cartons, special bargain offer, **37/6**, carr. 100-m. **6/-**, 200-m. **8/6**, 300-m. **11/-**. C.I., N.I. and I.O.M. **15/-.**

BARR & STROUD RANGEFINDER. 1-metre base, coincidence type, a hand-held instrument that gives range in yards of any distant object from 500 to 20,000 yards (12 miles). The variable focus 14 x right eyepiece provides two images of the object viewed; one from the right objective the other from the left. When these two images are brought into coincidence the range in yards can immediately be read in the left eyepiece. Fitted two filters and other refinements. A very high-quality instrument, original cost £180, our price new or near new condition, supplied in stout fibre containers, **£5**, carriage 100-m. **7/6**, 200-m. **10/-**, 300-m. **12/6**, N.I. **20/-.**

CHASSIS. U.S. manufacture all aluminium, 12½ x 8 x 5½in. complete with top cover some items have been removed, remaining are:—25 Amphenol midget ceramic B7G type v/holders, complete with cans, over 70 colour coded 5% resistors, also many ceramicons and other cons., trimmers, paddlers, fixed and variable inductances, transformer, v/control, etc., new, unused, bargain, **10/-**, post 3/6.

ZAMBONI PILES, dry voltaic type, consists of 3 piles, each 6in. long by 1in. dia. in high insulation mount to give 1500-v., taken from new unused infra-red receivers, **5/-**, post 1/6. also variable focus eyepieces and Wratten filter backed objectives taken from same instrument, **5/-** set, post 1/6.

RELAYS, all new unused, U.S. type, 7600-ohms, single pole make, size 2½ x 2 x 1¼in., **3/6**, post 9d., ditto, 60-ohms, 3-pole 3-make, size 1½ x 1½ x 1in., **2/6**, post 9d., Siemens H.S. relays, 145-ohms., single-pole changeover platinum contacts, in metal cases with terminal block, **5/-**, post 1/6, 5C/649 relays, 26-ohms, 9-14 v., single make 40-amp. D.C. contacts, in bakelite cases, 2½ x 2½ x 1¼in., **2/6**, post 1/-.

SIGHTING TELESCOPES by Ross, Taylor, Hobson, etc., these high quality instruments contain four 40 mm. dia. achromats, 2 of 3in. focal length, 2 of 3¼in. focal length, also an 18 mm. dia. image erector achromat, 4 screw fine adjustment cross graticule, length 16in., weight 7 lbs., new and boxed, **35/-**, post 3/3.

TELEPHONE SETS, consists of two combined microphones and receivers, which when wired up by ordinary twin flex, provides perfect 2-way communication, excellent results at 1 mile range have been reported, self-energised, no battery required, set complete, new unused, **7/6**, post 1/3; suitable twin 14/36 p.v.c. up to 300ft. lengths at 1d. per ft. supplied, postage each 20ft. flex 3d. extra.

TIME DELAY SWITCHES, 24 v. clockwork type by "Venner," in smart metal cases with external press wind, in addition to clockwork mechanism contains two electro-magnets, 5-pole cam-operated contacts, etc., new and boxed, **5/-**, post 1/6.

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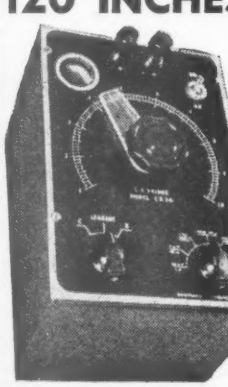

The CR50 Bridge covering 10pFd to 100mFd and 1 ohm to 10 Megohms in fourteen ranges has a total length of scale of over 120 inches, thereby ensuring easy and accurate readings. A leakage test is incorporated for condensers. Complete with valves, instructions and ready for operation from 200/250 volt A.C. mains. **£8/2/6** plus 4/6 carr./packing.

SG50 SIGNAL GENERATOR covers 100kc/s to 80Mc/s in six ranges on fundamentals. A de luxe instrument in heavy gauge metal case with engraved perspex scale. Ready for operation from 200/250 volt mains. **£9** plus 6/- carr./packing.

VV60 AUDIO VOLTMETER measures 1 milli-volt to 100 volts in five ranges. **£14** plus 4/6 carr./packing.

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TRADE supplied direct. CREDIT TERMS available.

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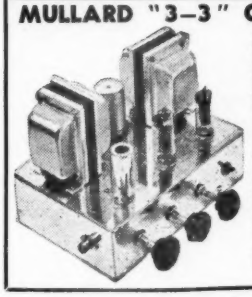
MULLARD "3–3" QUALITY AMPLIFIER



An ideal companion unit to the JASON Tuner. A really first-class 3-valve 3-watt Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line-up: EF86, EL84, EZ80. H/duty mains trans., giving extra HT and LT for Tuner Unit addition.

Variable treble cut and bass boost controls, sensitivity 100 MV for 3-watt output. Frequency response + or — 1db, 40 c/s to 25 kc/s.

Complete amplifier wired and tested with quality sectionalised output transformer to Mullard specification

(less speaker)
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Wired Power Output Socket with Additional Smoothing for F.M. Tuner 10/6 extra.

JASON F.M. TUNER UNIT 87-105 mc/s

Designer Approved Kit of parts to build this modern highly successful unit, drilled chassis and superior type dial. Coils, cans and all quality components, etc., for only 5 gns., post free. Set of 4 spec. EF91 or equiv. valves 30/-, post free. Illustrated handbook with full details, 2/-, post free—**Free with Kit, 48-hr. Alignment Service 7/6** and 2/- p. & p. **AND NOW—Jason "Mercury" Switched F.M. Tuner,** with A.F.C. Complete kit only 8½ gns., plus 2/6 p. & p.
Set of 3 × **E.F.80** valves, Special price **21/-.**

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TUBULAR	CAN TYPES
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8/500 v. 2/9	16+16/500 v. 6/-
8+8/500 v. .. 4/6	16+16+8/350v 5/6
8+16/450 v. .. 5/-	32+32/350 v. 5/6
16/450 v. 3/6	32+32/275 v. 4/6
16+16/450 v. 5/6	50+50/350 v. 6/6
32/350 v. 4/-	60/350 v. 6/6
32/500 v. 5/-	60+250/275v. 12/6
32+32/350 v. 5/6	64+120/275v. 11/6
32+32/350 v. 5/6	100+200/275v. 12/6
32+32/450 v. 6/6	100/270 v. 6/6

MIDGET TRANSISTOR TYPES. 2μF 4μF. 8μF, 6v. 3/6; 6μF, 10μF, 16μF, 3v., 3/6; 32μF, 1½v., 3/6.

CONDENSERS.—Silver Mica. All pref. values, 2 pf. to 1,000 pf. 6d. each. Ditto ceramics 9d. each. Tubulars 450 v. T.C.C. etc., .001 mfd.-.01 and .1/350 v., 9d. each. 02-1/500 v. 1/- each. .25 Hunts, 1/6. 5 T.C.C. 1/9. .001 6kv. 5/6. .001 20kv. 9/6.

CLOSE TOLERANCE CONDENSERS S/Mica. 10% Type. 5pf.—500 pf., each 1/-; 600 pf.—5,000 pf., each 1/3. 1% Type, 1.5 pf.—50 pf. (Tol. 1 pf.), 1/9; 56 pf.—500 pf. each 1/9; 575 pf.—5,000 pf., each 2/-.

RESISTORS.—Pref. val. 10 ohms 10M ohms.

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20% Type, ½ w., 3d.; ¼ w., 5d.; 1 w., 6d.; 6 w., 9d.	5 w. } 25 ohms—1/3 10 w. } 10,000 ohms 1/6 15 w. } 2/-
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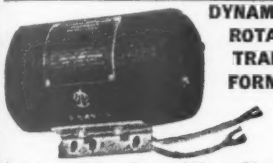

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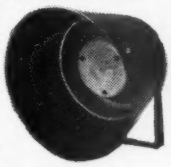

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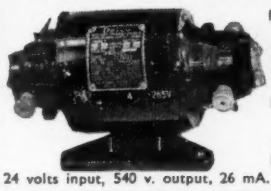

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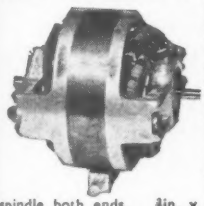

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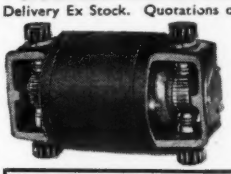

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Tenancy of a Company house will be available to the successful applicant if required.

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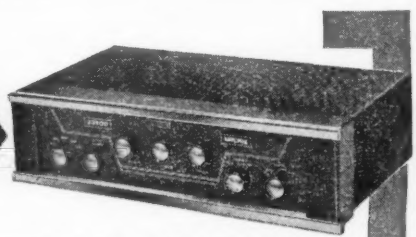

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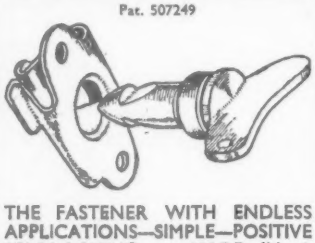

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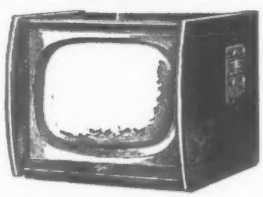

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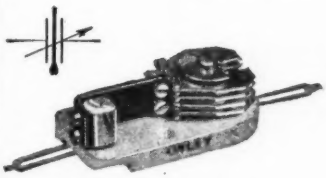

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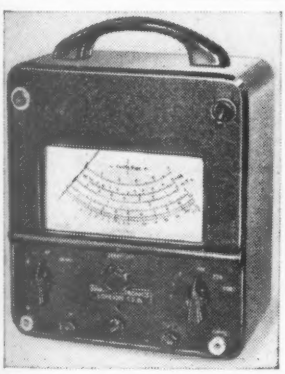

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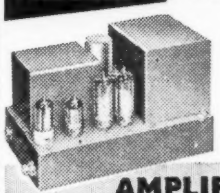

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50 WATTS INSTALLATION

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The installation consists of:
Transmitter BC-375 complete with 7 plug-in tuning units covering whole frequency range.
Receiver BC-348, range 200–500 kc/s and 1.5–18 mc/s, for 28 v. operation.
Antenna tuning unit.
Transmitter dynamotor power supply unit for 28 v. operation.
Interconnecting cables.
Headphone, microphone and key.

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Receiver.
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Remote control unit.
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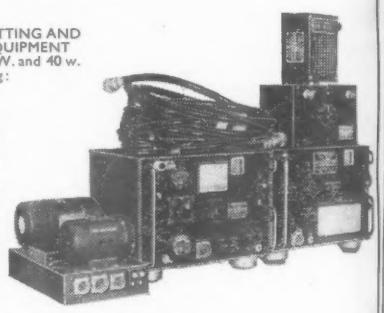

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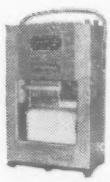

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This is an A.C./D.C. instrument of the moving coil type, A.C. range being obtained through an internal metal rectifier. Separate terminals are brought out for A.C. and D.C. A.C. range 1 milliammeter; D.C. range approx. 0.9 mA F.S.D. Clock driven chart 1 inch per hour.
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MARCONI CR-100 receiver, 50 kc/s to 30 mc/s, mains operated. **£30.** P.P. £1.
MARCONI CR-150 receiver, 2–60 mc/s, dual superhet. **£50.** Mains power supply unit **£10.** Packing and carriage £1.
HALLICRAFTER S-27 receiver, 27–143 mc/s, F.M./A.M. reception, mains operated. **£32.** P.P. £1.
HALLICRAFTER S-27C receiver, 130–210 mc/s, F.M./A.M. reception, 115 v. A.C. supplies. **£50.** P.P. £1.

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5in. mirror scale, dual range, 150/300 v. A.C./D.C. **£5/19/6.**
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Readers are warned that Government surplus components and valves which may be offered for sale through our displayed or classified columns carry no manufacturers' guarantee: Many of these items will have been designed for special purposes making them unsuitable for civilian use, or may have deteriorated as a result of the conditions under which they have been stored. We cannot undertake to deal with any complaints regarding any such items purchased.

NEW RECEIVERS AND AMPLIFIERS

SHIRLEY LABORATORIES, Ltd., 5, Prospect Place, Worthing, Sussex Tel. 30536. THE TWA/1515 stereosonic tape recording and replay amplifier, separate meter monitoring on record and playback on both channels, 13watts O/P each channel, 96gns. TWA/15 tape recording and reproducing amplifier, 13watts O/P, for Wearite and Collaro decks, 45gns; TW/PA recording and replay pre-amplifier, 30gns; both with valve voltmeter monitoring; type SB/1-15E high-fidelity amplifier exceptionally wide tone-control system, 40mv sensitivity, 20gns; with two inputs and 3-position gram filter, 22gns; specialized amplifiers for the musical and scientific industries including the Mullard 30watt. [0095

RECEIVERS AND AMPLIFIERS—SURPLUS AND SECONDHAND

HRO Rx's and coils in stock, also AR88, BC348R, CR100, etc.—Requirements please to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0053

G.E.C. amplifier equipment, complete with radio unit; gramophone turntable and pick-up and amplifier consisting of 2 DA 100 valves in final stage; contained in 6ft steel rack and capable of supplying 60 speakers; complete with 35 speakers.—Offers to P.R.I., 68th Regt. R.A., Park Hall Camp, Oswestry, Salop. [7869

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PHILIPS 17in projection televisions available, as taken in part exchange, complete, but not guaranteed; £9/15, originally £92-£120 each.—Tomlins, 127, Brockley Rise, Forest Hill, S.E.23. [0343

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TRANSMITTING EQUIPMENT—SURPLUS AND SECONDHAND

BENDIX Tranx TA12G 300kc—9Mc in 4 bands, 7 valves, only £5 ea., carr. 15/-; Oscillator wavemeter C.R.1., 148-208Mc, has 8 valves, cables, etc., for 115v 50c/s, mains, bargain, £5ea., carr. 10/-; receiver R9.B/APN4, has 1-6SN7, 1-6SL7, 1-6H6, 4-6SK7, 1-6SA7, 1-6Q4G, 3-6B4G, 2-2x2, 1-6SJ7, 1-VR150/30, new, boxed, 45/- ea., carr. 10/-; mainland only, free lists.— Annakin, 25, Ashfield Place, Otley, Yorks. [7918

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GEC miniscope in carrying case, as new. Perfect,. with plug-in I.F. alignment unit; £16 or offer.—11, Byron Rd., Selsdon, S. Croydon. Sanderstead 3346. [7894

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DEMONSTRATIONS can be arranged in London.—For full details write to K.T.S., Ltd., "Coplow," Park Rd., Braunton, N. Devon. Callers by appointment only. [0210

GLASGOW.—Recorders bought, sold, exchanged, cameras, etc., exchanged for recorders or vice versa.—Victor Morris, 406, Argyle St., Glasgow, C.2. [0201

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FOR SALE AND WANTED ADVERTISEMENT FORM TURN TO PAGE No. 165

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WANTED, 2000-1750-1500-0-1500-1750-2000 volt 800 MA transformers as made by Thermador, etc.—Box 6390. [7906

WANTED, disc recording equipment, 3-speed must be modern studio or portable. —Box 6456. [7922

WANTED, Garrard or Connoisseur transcription unit, variable speed, G.E.C. 912 Plus amplifier.—J. D. Johnston, Ranchi, South Biggar Rd., Airdrie. [7921

WANTED, HRO coils, Rxs., etc., A.R.88s, BS348s, S27s, etc.—Details to R. T. & I. Service, 254, Grove Green Rd., London, E.11. Ley. 4986. [0163

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WANTED, BC610 Hallicrafters, E.T.4336 transmitters, BC312 receivers, BC221 frequency meters and spare parts for all above; best cash prices.—P.C.A. Radio, Beavor Lane, Hammersmith, W.6. [0079

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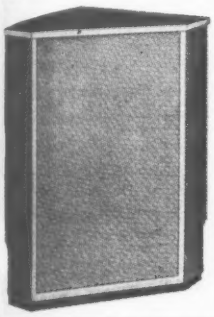

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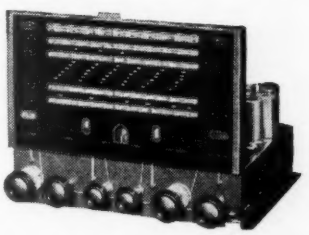

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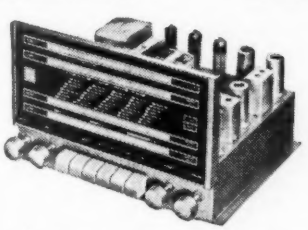

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RADIO TECHNICIANS of all grades are invited to apply for interesting and varied positions in car radio servicing, installation and development. Vacancies also occur from time to time for our dealers in all parts of the country. A high standard of practical and theoretical knowledge is required. Good wages, 5 day week and staff pension scheme.—Apply in writing to the Staff Manager at Cricklewood Works, London, N.W.2, quoting reference SM/116 [7916

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FOREMAN required for expanding firm of electronic instrument manufacturers, north-west London area, good salary and prospects.—Write Box 5504 [7828

CHIEF Engineer required for progressive company in west Surrey. Applicant must have first class practical experience in, as well as theoretical knowledge of, electronic instruments, engineering and small mechanisms. Salary £1,500 per annum. Apply—Box 6240. [7895

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THE work will cover a wide field, including transistors, stereo and V.H.F. Applicants mainly interested in television should be familiar with the problems associated with negative modulation.
SALARY will depend on experience and qualifications, but will not be less than £1K to the right man.
WRITE with full details of age, experience and qualifications to the Personnel Manager (R.14), Murphy Radio Ltd., Welwyn Garden City, Herts. [7884

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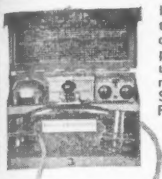

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REPLIES, treated strict confidence, should state all details including salary required.—Box 6458. [7928

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TELEVISION bench and field engineers required at all times for vacancies in most parts of the British Isles; permanent positions with highest salaries, plus bonus for suitable applicants; 5½-day week.—Box 2781. [0251

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ELECTRONIC engineers required to fill one senior and one junior position in test engineering dept. concerned with design and maintenance of production test equipment. New projects involving VHF, transistors and printed circuits demand expansion of this dept. with engineers, preferably experienced in one or more of these fields.
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amplifier circuit using KT 88's and SAVAGE MASSICORE transformers

Amplifier employing ten KT 88's 400 Watts as described by G. R. Woodville in the "Wireless World," November, 1957.

OUTPUT TRANSFORMER TYPE 4T35

1,000 ohms centre tapped and tapped at 40% Secondary impedances: Four sections each 25v.

APPROXIMATE ELECTRICAL CHARACTERISTICS

Primary inductance: 10 hys.
Primary D.C. resistance: 6.5 ohms+6.5 ohms.
Leakage reactance: Primary to secondary 1 m/hy.
Half primary to secondary 0.5 m/hy.
Power handling capacity: 400 watts at 50 c/s.
Size: 6½in. x 5½in. x 7in. high. Weight 25 lbs.
Potted 4T35C Size: 7½in. x 6in. x 7½in.
Weight 30lbs.

MAINS TRANSFORMER TYPE 5A9-1

Primary: 200/250v 50 c/s single phase.
Secondary: 700v. 1.2A DC bridge rectifier.
Size: 8½in. x 6½in. x 8½in. high. Weight: 52 lbs.
Potted 5A9-1C Size: 9½in. x 8in. x 7½in. high.
Weight: 55 lbs.

MAINS TRANSFORMER TYPE 5A9-2

Primary 200/250v. 50 c/s single phase.
Secondary: 150-0-150v. 20mA.
2.5v. 10A
2 x 2.5v. 5A.
6.3v. 20A
Size: 5½in. x 4½in. x 5½in. high. Weight: 15 lbs.
Potted 5A9-2C Size: 5½in. x 4½in. x 6½in. high.
Weight: 16 lbs.

CHOKE TYPE 5A9-3

2 hys 1.2A DC D.C. resistance 18 ohms approximately
Size: 4½in. x 3½in. x 4½in. high. Weight: 12 lbs.
Potted 5A9-3 C Size: 5½in. x 4½in. x 5in. high.
Weight: 13½ lbs

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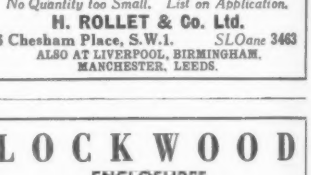

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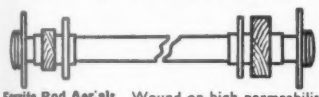

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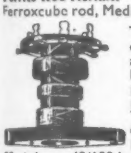

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This has been designed to eliminate the principal causes of I.F. interference: R.F. Heating Equipment, Diathermy Equipment, Industrial and Medical Equipment, Local Oscillators, Forward Scatter Transmissions.

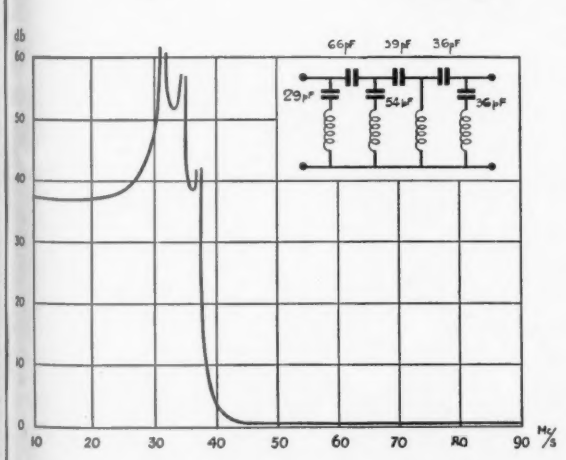
Where a requirement arises for a completely assembled and screened high-pass filter, then Type C.263 can be supplied in an aluminium can, having a co-axial socket mounted at one end and a short length of co-axial feeder, suitably terminated with a plug, at the other end. By this means the filter may be connected directly in series with the aerial feeder of a T.V. receiver and no further adjustments would be necessary.

The unit offers very high attentuation at frequencies of 38 m/cs. and below, and thereby prevents pick-up of the interfering signal by the I.F. Amplifier circuits.

This unit has been approved by and supplied to the G.P.O.

The dimensions of the can are: $4\frac{1}{2}''$ x $1\frac{1}{2}''$ diameter with a co-axial lead 9" long.

The unscreened units can be offered to manufacturers for direct installation in their equipments. Further details may be had on application.



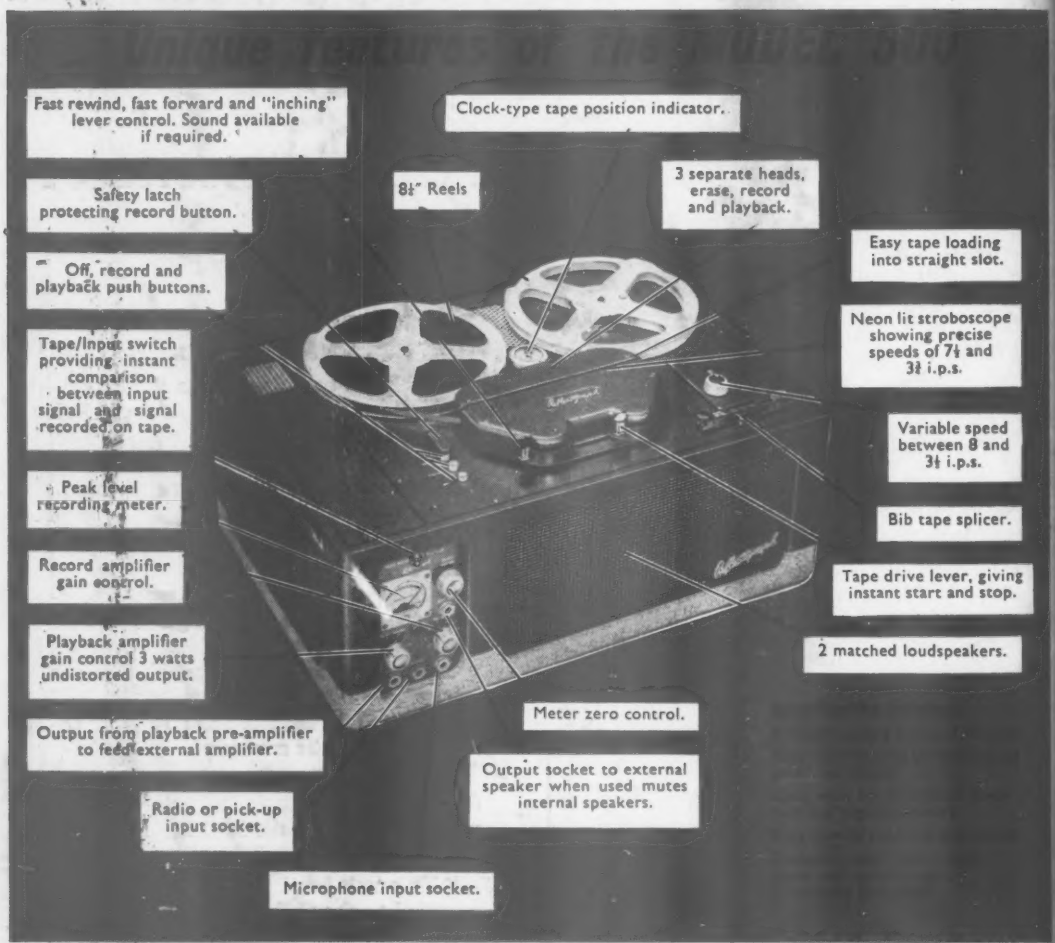
List Price **29/6** each.

THE TELEGRAPH CONDENSER CO. LTD

RADIO DIVISION · NORTH ACTON · LONDON · W.3 · Tel: ACOrn 0061

Reflectograph

PROFESSIONAL RECORDERS FOR THE HOME


Fast rewind, fast forward and "inching" lever control. Sound available if required.
Clock-type tape position indicator.
Safety latch protecting record button.
8½" Reels
3 separate heads, erase, record and playback.
Easy tape loading into straight slot.
Off, record and playback push buttons.
Neon lit stroboscope showing precise speeds of 7½ and 3¾ i.p.s.
Tape/Input switch providing instant comparison between input signal and signal recorded on tape.
Variable speed between 8 and 3¾ i.p.s.
Peak level recording meter.
Bib tape splicer.
Record amplifier gain control.
Tape drive lever, giving instant start and stop.
Playback amplifier gain control 3 watts undistorted output.
2 matched loudspeakers.
Meter zero control.
Output from playback pre-amplifier to feed external amplifier.
Output socket to external speaker when used mutes internal speakers.
Radio or pick-up input socket.
Microphone input socket.

REFLECTOGRAPH 400

Reflectograph 400 is supplied in three units for incorporation in furniture: it comprises the Reflectograph deck mounted on a stand, combined record amplifier and playback pre-amplifier and the power pack. The units, complete with inter-connecting leads, have been designed for operation in conjunction with the leading makes of high fidelity amplifiers.

Additional facilities include sockets on chassis for radio and pick-up; socket for microphone on instrument panel, where an additional switch provides instant selection of microphone, radio or pick-up.

STEREO CONVERSION UNITS

Models 440 and 540 enable owners of Models 500 and 400 to have their instruments converted to reproduce stereo tapes and records.

The original models have to be returned to the factory for the fitting of the stereo head.

REFLECTOGRAPH 550

Reflectograph 550 possesses all the recording features of Model 500. The fine walnut lowboy cabinet does not incorporate loudspeakers. Two 3 watt undistorted amplifiers provide ample power for reproducing stereo tapes or discs if a suitable pick-up is connected. For single channel reproduction the amplifiers are automatically switched in parallel.

REFLECTOGRAPH 450

Reflectograph 450 has the same technical features as Model 550. It is supplied in 3 units for incorporation in furniture.

Prices in U.K. only. 500 — 94 gns. 400 — 84 gns. 540 — £37.6.8 440 — £36 550 — 133 gns. 450 — 103 gns.

MULTIMUSIC LTD., MAYLANDS AVENUE, HEMEL HEMPSTEAD, HERTS. TELEPHONE: BOXMOOR 3636

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